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THE CAT.

THE SKELETON, SHOWING THE RELATIO

TO THE EXTERNAL FORM.

THE CAT.

AN INTRODUCTION TO THE STUDY

OF

BACKBONED ANIMALS

ESPECIALLY

MAMMALS.

By St. GEORGE MIVART, Ph.D., F.R.S.

WITH 200 ILLUSTRATIONS

NEW YORK
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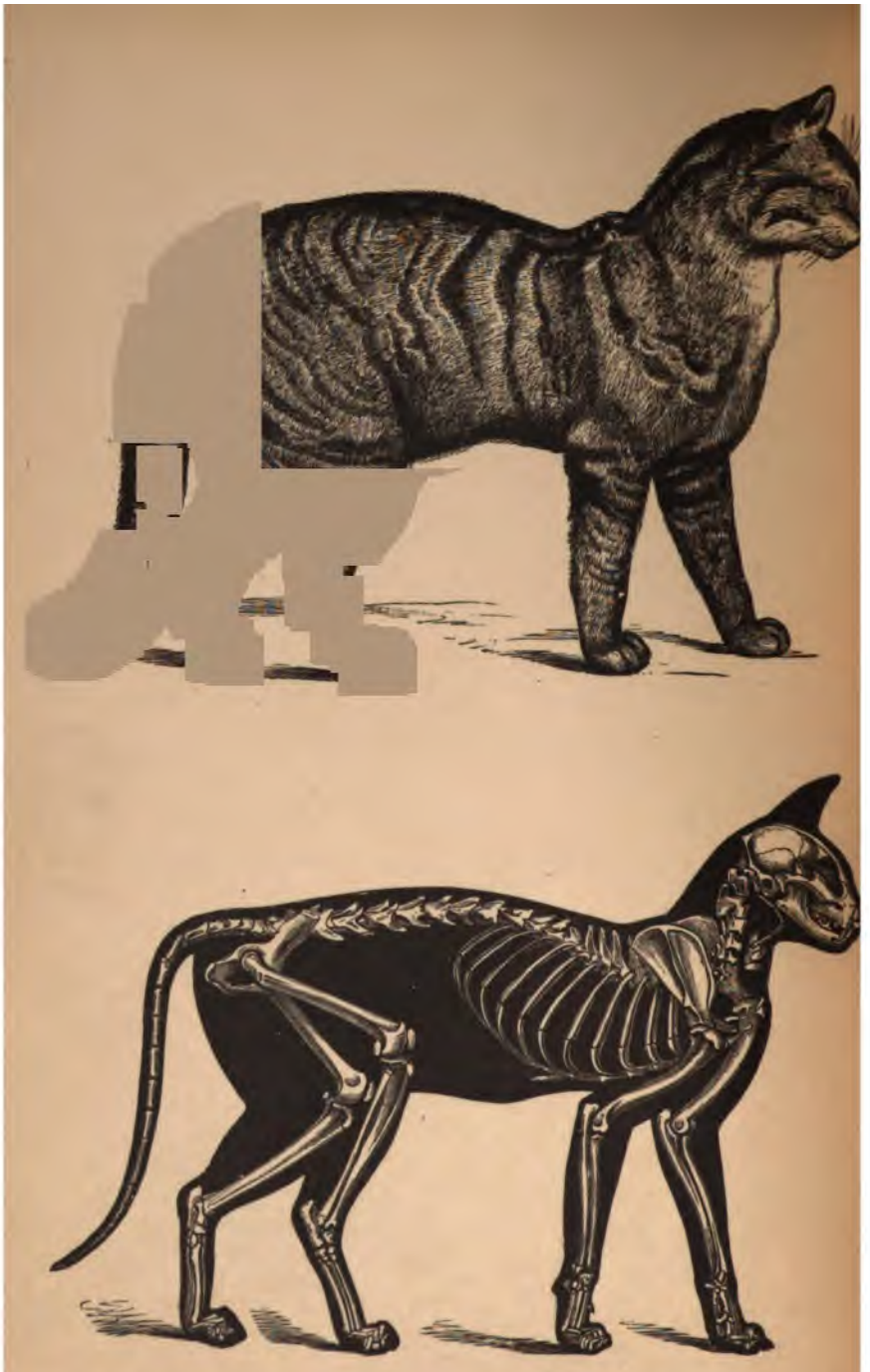

EXTERNAL FORM OF WILD CAT AND FIGURE OF THE SKELETON, SHOWING THE RELATIO
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ESPECIALLY

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BY [illegible] GEORGE MIVART, [illegible], F.R.S.

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followed. The bodily structure most interesting to man, his own, was the first studied (directly or indirectly), and the names now given to different parts of the bodies of the lower animals have been mainly derived from human anatomy. The descending course is also that which seems, on the whole, preferable, for thus, by commencing with the class of animals to which man belongs, we may proceed from the more or less known to the unknown, and from that which is comparatively familiar, to that which is strange and novel.

Having then chosen to begin the study of Animals and Plants with that class to which we belong, it might perhaps be expected that Man himself would be chosen as the type. But a fresh description of human anatomy is not required, and would be comparatively useless to those for whom this work is especially intended. For a satisfactory study of animals (or of plants) can only be carried on by their direct examination—the knowledge to be obtained from reading being supplemented by dissection. This, however, as regards man, can only be practised in medical schools. Moreover, the human body is so large that its dissection is very laborious, and it is a task generally at first unpleasing to those who have no special reason for undertaking it. But this work is intended for persons who are interested in zoology, and especially in the zoology of beasts, birds, reptiles, and fishes, and not merely for those concerned in studies proper to the medical profession.

The problem then has been to select as a type for examination and comparison, an animal easily obtained and of convenient size; one belonging to man's class and one not so different from him in structure but that comparison between it and him (as to limbs and other larger portions of its frame) may readily suggest themselves to the

student. Such an animal is the common Cat. In it we have a convenient and readily accessible object for reference, while the advantages which would result from the selection of Man as a type will almost all be obtained without the disadvantages of that selection. The study of the zoology of the Cat, as here treated, will also give the earnest student of Biology the knowledge of anatomy, physiology, and kindred sciences, which is necessary to enable him to study profitably the whole class of animals to which it belongs and to which we belong—the class of *Mammals*. The natural history of that entire class will be treated of in a companion volume, to which the present work may serve as an introduction—all the needful anatomical terms and relations (as they exist in the selected type) being here once for all explained. The present volume is expressly intended to be an introduction to the natural history of the whole group of *back-boned animals* (since they are all formed according to one fundamental plan); but the subject has been so treated as to fit it also to serve as an introduction to Zoology generally, and even to Biology itself: the main relations borne by cats, not only to the leading groups of animals, but also to plants, being here pointed out. The sciences subordinate to Biology are also enumerated and defined.

It has been thought better not to separate the study of physiology from that of anatomy, and, accordingly, an explanation of the functions performed by each different system of parts of which the body is made up, will be found to follow the account of their structure.

I am indebted to my friend Professor Flower for the use of his valuable illustrations of the skulls of the Carnivora, as also to the Zoological Society, from whose Proceedings they are, with some other illustrations, extracted. I desire also to express my thanks to Professor Allen

Thomson, M.D., F.R.S., and to Messrs. Longmans & Co., Messrs. Cassell & Co., and Messrs. Kegan Paul & Co., for the use of various electros.

Dr. Murie, F.L.S., has had charge of many of the wood-cuts, certain of which—representing ligaments, viscera, and salivary glands—have been drawn from his dissections and under his supervision.

I have to thank Mr. Alban Doran, who has made careful dissections of the internal ear and portions of the generative organs, and also Mr. P. Percival Whitcomb and my son Mr. Frederick St. G. Mivart, for more or less assistance. To Professor Cope I am much indebted for very kindly sending me proofs of unpublished plates of American fossils described and named by him.

I have also to express my obligation to Mr. Wm. Pearson (of the College of Surgeons) for making some excellent dissections, from which certain of the illustrations are taken. Original drawings have also been made from specimens preserved in the museum of the Royal College of Surgeons and in the British Museum. The drawings have (with the exception of six figures of fossil remains) been executed by Mr. C. Berjeau and engraved by Mr. Ferrier. I feel bound to express my sense of the skill evinced in their execution.

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THE CAT.

CHAPTER I.

INTRODUCTORY.

§ 1. WHETHER it is the Cat or the Dog which is the most domestic of all our domestic animals, is a question which may be disputed. The greater intelligence and affection of the dog, cause men generally to prefer it to its rival. As the eager partner of our sports, or the faithful guardian of house or homestead, it is of especial value. Yet the cat is so largely self-supporting and so useful an ally against unwelcome intruders, that it is the inmate of a multitude of humble homes wherein the dog has no place. The cat also is favoured by that half of the human race which is the more concerned with domestic cares; for it is a home-loving animal and one exceptionally clean and orderly in its habits, and thus naturally commends itself to the good will of the thrifty housewife.

Moreover, though it is generally much less demonstrative in its affection than is the dog, yet cats differ as men do, and some individuals manifest strong feelings of regard for one or other members of the family wherein they make their homes.

Cats are even sometimes made use of to obtain food for their owners, the latter availing themselves of the habit which cats have of bringing home prey.*

The Domestic Cat is an animal so common and familiar that its utility is sometimes apt to be lost sight of. To realise its usefulness we must imagine ourselves in a land where no such an animal is known, but where the annoying creatures upon which it preys shall have multiplied with that rapidity natural to them. The familiar tale of Whittington may serve to illustrate what would be the effect of its introduction into such a land. It has been calculated that a single cat may devour twenty mice in one day; but this of course is by

* Thus, several rabbits will sometimes be brought home by a cat in a single day.

no means the limit of its powers of destruction. Its effect in putting to flight the creatures it pursues, is again far in excess of its destructive energy. Were every cat in England simultaneously destroyed, the loss through the entailed increase of vermin would be enormous.

§ 2. But however much this animal may deserve our esteem, or win our admiration, by its shapely form and graceful movements, it certainly has very special claims on the attention of lovers of biological science. For in the first place its organization, considered absolutely in itself, is one of singular perfection, and the adaptation of means to ends which it displays is truly admirable. If, however, we compare its organization with that of other animals, we shall by so doing not only gain a better appreciation of its structural perfections, but also become acquainted with a variety of relations conveying useful lessons in anatomy, psychology,* and zoology, and others referring to the past, the present, and even the future history of this planet.

§ 3. The "Common" (domestic) Cat of our country, and indeed of the continent also, is not the "Common Cat" of zoology. The latter is of course the originally native cat—or wild cat. The domestic and the wild cat may, however, for our present purpose, be considered together, and, thus considered, the events of the last two thousand years have strangely altered the distribution of the cats of this country.

That men dwell in cities, instead of in woods, is one effect of civilization. A similar but greater change has been produced with English cats by the same cause. For when Julius Cæsar landed here our forests were plentifully supplied with cats, while probably not a single mouser existed in any British town or village. The word "cat" appears to be of Roman origin, being probably derived from the Latin word *catus*, which word also seems to have been at the same time the root of the Greek κατ-τα, the old German name *chazza*, and of the softened French form of the word, *chat*. The original derivation of the name does not, however, appear to have been as yet ascertained. It occurs in Anglo-Saxon writings with the spelling Catt.

It might be supposed that our present domestic cat is simply our own ancient wild cat tamed; but had it been so and therefore been easily procurable, it would not have been so highly valued as it was even so late as a thousand years after the Roman invasion. But though the domestic cat was thus rare, and therefore precious, the wild cat continued to be common in England during the Middle Ages. This is proved by the fact that its fur was then commonly used for trimming dresses.

A canon, enacted in the year 1127, forbad any abbess or nun to use more costly fur than that of lambs or cats, and the cat was an object of chase in royal forests, as is shown by a license to hunt it of

* The word Psychology is here used in its wide and (as the author believes) in its proper sense as embracing Physiology within its scope.

he date 1239, and by a similar charter given by Richard the Second o the Abbot of Peterborough.

The Wild Cat is now (thanks to the destruction of our forests, he introduction of fire-arms, and the over-zeal of game-keepers,) xtinct in England, and perhaps in Wales also, though it lived ere till within fifty, and in Wales till within twenty years ago. In reland it seems never to have existed, and the stories we read of rish wild cats probably refer to the progeny of domestic cats run vild. This is the opinion of Dr Hamilton, F.Z.S., who has paid reat attention to this subject, and carefully collected and investigated he evidence as to the existence of the wild cat in Ireland. In Scotland t is still far from uncommon, and is especially frequent in Inverness, Ross-shire, Sutherland, and on the west coast of the Highlands, where he recent increase of rabbits (animals so useful to it as good food,) eems to have occasioned some increase in the number of wild ats. These animals exist also in Skye, but not in the Western sles.

On the continent the wild cat is found in Southern Russia, and he adjacent parts of Asia, Turkey, Greece, Hungary, Germany, Dalmatia, Spain, Switzerland, and, though now very rare, France.* t does not appear to exist in Norway or Sweden.

§ 4. Our Domestic Cat seems to have come to us (like our other omestic animals) from the East, and is probably a descendant of he old domestic cat of Egypt, which, as the granary of the ancient orld, might well have been the country in which the animal was riginally tamed. In the Egyptian Gallery of the British Museum s an excellent painting of a tabby cat, which seems to be aiding a nan who is capturing birds. It is mentioned in inscriptions as early s 1684 B.C., and it was certainly domesticated in Egypt thirteen undred years before Christ. The earliest known representation of he cat as a domestic animal and pet, is at Leyden in a tablet of the 8th or 19th dynasty, wherein it appears seated under a chair. n Egypt, it was an object of religious worship and the venerated nmate of certain temples. The goddess Pasht or Bubastis, the oddess of Cats, was, under the Roman Empire, represented with a at's head. A temple at Beni-Hassan, dedicated to her, is as old as Thothmes IV. of the 18th dynasty, 1500 B.C.† Behind that temple

* One wild cat at the least has been killed in France between 1815 and 1830.

† Dr. Birch has kindly informed me that the earliest representation of the cat, with which he is acquainted, the date of which is certain, is on tomb No. 170 of the Berlin Museum, apparently of about 1600 B.C.; but that it also figures on a tablet which from its style appears to be two hundred years older—as part of the name of a woman, "Mau" or cat. It also appears in hunting scenes of the 18th dynasty, and in rituals written under that dynasty, but probably repetitions of a much earlier text. It is mentioned in the 17th chapter of the Ritual, and the coffins of the 11th dynasty are inscribed with that chapter, which, according to Lepsius, would carry us back to about 2400 B.C. In a copy of the Ritual of B.C. 1500, its 33rd chapter has the text, "thou hast eaten the rats hateful to Ra (the Sun), and thou feedest on the bones of the impure cat." In Egypt an animal, though sacred in one city, might be regarded as impure in another city.

are pits containing a multitude of cat mummies. The cat was an emblem of the sun to the Egyptians. Its eyes were supposed to vary in appearance with the course of that luminary,* and likewise to undergo a change each lunar month, on which account the animal was also sacred to the moon. Herodotus (ii. 66) recounts instances of the strangely exaggerated regard felt for it by the dwellers on the Nile. He tells us that when a cat dies a natural death in a house, the Egyptians shave off their eyebrows, and that when a fire occurs they are more anxious to save their cats than to extinguish the conflagration.

From Egypt it must have been introduced into Greece, and the intimate knowledge of Egyptian customs which became common in Rome from the time of Julius and Augustus must have brought into it amongst many other animals a knowledge of the domestic cat. A fresco painting of such a cat was discovered in Pompeii †

It was not a domestic animal amongst the Hebrews, though it was known in India two thousand years ago.

It has been suggested by Professor Rolleston,‡ that the domestic animal of the Greeks (used by them for the purposes for which we now use the cat) was the white-breasted marten. But however this may be, there can be no question as to the cat having been domesticated in Europe before the Christian era. There are signs that it was domesticated amongst the people of the Bronze period, and the supposition that it was first introduced into Western Europe by the Crusaders, is of course an altogether erroneous one. They may however have introduced a distinct race, for if it be true that our domestic cats have mainly descended from the Egyptian cat, it does not follow but that blood from other sources may have mingled with that of the Egyptian breed.

Pope Gregory the Great, who lived towards the end of the sixth century, is said to have had a pet cat, and cats were often inmates of nunneries in the Middle Ages. The great value set upon the cat at this period is shown by the laws which in Wales, Switzerland, and Saxony, and other European countries, imposed a heavy fine upon cat-killers. As compensation, a payment was required of as much wheat as was needed to form a pile sufficient to cover over the body of the animal to the tip of its tail, the tail being held up vertically, with the cat's muzzle resting on the ground.

The Wild Cat (*Felis catus*) differs from our ordinary domestic cat in that it is more strongly built and larger, with a stouter head and shorter and thicker tail, which is not tapering but of about the same thickness throughout. Its whiskers also are more abundant, and the soles of its feet are, in the males, deep black. Its body is of a yellowish-grey colour, with a dark longitudinal mark along the

* Mr. J. Jenner Weir has found that the eyes of cats will really change colour.

† See Plate 81 of Raccolta de piu belli Dipinti, from the collections in the Royal Museum (Napoli, 1854). The cat is represented as seizing a thrush, and is very well drawn.

‡ See Cambridge Journal of Anatomy and Physiology, 1868, vol. ii. pp. 47 and 437.

back, and with numerous darkish stripes descending more or less vertically down the sides, and marking transversely the limbs. Its tail is ringed with black, and is black at the end. It is thus marked like the domestic variety called "tabby." One killed near Cawdor Castle measured 3 feet 9 inches from its nose to the end of its tail.* Its savage disposition is very early shown, even the young kittens spitting vigorously at anyone who approaches them. The female makes her nest in hollow trees and the clefts of rocks, and sometimes uses the deserted nest of some large bird.

§ 5. The EGYPTIAN CAT (*Felis maniculata*) is a native of northern Africa, and was the parent of the cat tamed by the Egyptians, and —if what has been here urged is correct—also of our own domestic cat, possibly with an admixture of other blood.

The Egyptian cat is said to be about one-third smaller than the European wild cat. It is of a yellowish colour, somewhat darker on the back and whitish on the belly. There are some obscure stripes on the body, which become more distinct on the limbs. The tail is more or less ringed towards its termination, which is black.

§ 6. Although the differences between the various breeds of the DOMESTIC CAT are small indeed compared with those between different races of dogs, still very distinct varieties exist, but their distinctions repose mainly on the colour and the length or quality of the fur, and not on differences of form, such as those we find existing between the Greyhound and the Pug, the Spaniel and the Mastiff.

The colours of cats may be divided into black, white, tabby, sandy tortoiseshell, dun, grey, and what is termed "blue." There are also cats in which these various colours are more or less mixed.

The grey cat is very rare. It is, in fact, a tabby, without the black stripes, except two large stripes over the fore-legs—marks present in most spotted or striped cat-like animals of whatever species.

Black cats are remarkable for the clear yellow colour of their eyes. Their coat is rarely entirely black, for there are generally a few white hairs on the throat at the least. When young they show more or less perceptible striped markings.

White cats may have blue eyes, or eyes of the ordinary colour—that is, an obscure yellow with a tinge of green.

Those with blue eyes are generally deaf, but they are not always so. It often happens that the eyes of a white cat are not alike in colour; thus one may be blue and the other yellow.

The late Mr. John Stuart Mill told my friend Mr. John Jenner Weir, F.L.S.,† that he had at Avignon a breed of cats the eyes of which distinctly changed colour when the animals were excited.

* Mr. Harrison Weir tells me that the largest domestic cat he has seen weighed twenty-three pounds.

† This gentleman has acted as judge at numerous cat shows, and I am indebted to him for very kindly furnishing me with his notes respecting varieties of the domestic cat.

The tabby cat may be the result of the occasional crossing of the domestic cat by the wild cat. That they do breed together occasionally is certain,* and indeed races of domestic cats of different parts of the world will breed with wild cats of the same region.

The tortoiseshell cat should be fawn-coloured, mottled with black. Cats thus marked are almost invariably females, while sandy-coloured cats are almost always males. It appears that the sandy tom cat is the male of the breed of which the tortoiseshell is the female—the litters being almost invariably so divided. This fact is very interesting, because the sexes of cat-like animals are similarly coloured.†

Sometimes, however, sandy cats are female, and there is at least one good instance of a true tortoiseshell tom cat. Such cats, indeed, have not unfrequently been offered, by letter, to the Secretary of the Zoological Society, at very extravagant prices. Probably many of them were male cats of three colours—such as white and tortoiseshell and grey-white and sandy—but not the true tortoiseshell.

The Royal Siamese cat is of one uniform fawn colour, which may be of a very dark tinge. There is a tendency to a darker colour about the muzzle—as in pug dogs. It has also remarkable blue eyes, and sometimes, at the least, two bald spots on the forehead. It has a small head.

The blue or Carthusian cat is a breed with long, soft hair of a uniform, dark greyish-blue tint, with black lips, and black soles to the paws.

The Angora, or Persian cat, is remarkable for its great size, and for the length and delicacy of its hair, especially of the belly and throat. Most commonly its coat is of a uniform white, yellowish or greyish colour, while the soles of its paws and its lips are often flesh-coloured. Its temperament is said to be sometimes exceptionally lethargic; but this is certainly not always the case, and may be due to excessive petting for generations. This breed is believed by some naturalists to be descended from an Asiatic wild cat,‡ with a shorter tail than that of the Egyptian cat. It is commonly reported in works on Natural History that there is in China a breed of cats with pendent ears; but the Père David§ regards the assertion as an absurd fable. He has repeatedly sought to find such animals, but has never been able to see any, or to learn that they existed.

* This has been ascertained by Mr. A. H. Wills, who succeeded in getting the wild and domestic cat to breed together in confinement. (See Land and Water, Sept. 4th, 1875; and the Zoologist for 1873, p. 3574; and for 1876, pp. 4867 and 5038.) Mr. S. C. B. Pusey has also successfully crossed the wild and domestic cat, and several kittens resulting from this cross have been sent to the gardens of the Zoological Society of London. This interbreeding is remarkable, seeing that the period of gestation of the wild cat is sixty-eight days, or twelve days longer than that of the domestic animal.

† The only exception I have met with is the Yaguarondi of America, in which species the female is said to be of a lighter and brighter colour than the male.

‡ Pallas says that cats like the Angora cat are brought to Siberia from China. Zoographia Russo-Asiatica, vol. i. p. 28, note 3.

§ The well-known Lazarist missionary and naturalist, who has made so many interesting discoveries in China and Thibet.

In Pegu, Siam, and Burmah, there is a race of cats*—the *Malay Cat*—with tails only of half the ordinary length, and often contorted in a sort of knot, so that it cannot be straightened.† The true short-tailed or tailless cat—the Manx Cat—has also the hind-legs relatively long. Mr. J. J. Weir tells me he has seen one which had the fore-legs so short as to be useless in walking, and the animal sat up like a kangaroo.‡

Tailless cats are not, however, the only cats to be found in the Isle of Man; some cats there have tails ten inches long,§ a fact probably due to the introduction of long-tailed cats from England, Scotland, or Ireland. In cross-breeding the progeny seem generally to resemble the father as to length of the tail.‖ A tailless breed of cats also exists in the Crimea. The *Mombas Cat* of the coast of Africa is said to be¶ covered with short stiff hair instead of the ordinary sort of hair. The *Paraguay Cat*** is but a fourth of the average size of our domestic cats, has a long body with short, shiny, scanty hair, which lies close, especially on the tail. In South America there is said to be also a race of cats which have ceased to give forth cries like those by which our own cats are wont to give expression to their emotional sensibility. It is to be wished that this last breed should be introduced into this country. Yet the breed would probably not persist, for the reason which seems to limit the formation of new races; for the wandering nocturnal habits of the species defeat most attempts at selection in breeding.

That variations which might serve for the formation of new breeds must be every now and then forthcoming, is indicated by such facts as the following one, for a knowledge of which I am indebted to Mr. John Birkett.

A female cat had its tail so injured by the passage of a cart-wheel over it, that her master judged it best to have her tail cut off near the root. Since then she has had two litters of kittens, and in each litter one or more of the kittens had stumps of tails, while their brothers and sisters had tails of the usual length. Mr. Birkett himself saw one of the stump-tailed kittens. It is of course possible that the mother had some trace of Manx blood in her, but it is not likely, and the occurrence of the phenomenon just after, and only after, the accident and amputation, seems to indicate that in this perpetuation of an accidentally deformed condition, we have an example of the origination of a new variety.

* See J. Crawford's Descriptive Dictionary of the Indian Islands, p. 255.

† Its contortion is due to deformity of the bones of the tail.

‡ In the Museum of the Royal College of Surgeons there is preserved the skeleton of a cat, formerly belonging to the late Mr. Doubleday, the entomologist. This cat was born without any fore-limbs, yet could jump so well as to be able to jump up on a table. All the bones of the fore-limb are entirely wanting, save the shoulder-blades.

§ Mr. Bartlett assures me he has measured cats' tails in the island, and found all lengths up to ten inches.

‖ See Mr. Orton's Physiology of Breeding, 1855, p. 9.

¶ See Captain Owen's Narrative of Voyages, vol. ii. p. 180.

** See Reugger's Säugethiere van Paraguay, 1830, p. 212.

The direct influence of external circumstances upon different kinds of cats is worthy of note. Thus Captain Owen, R.N., (already referred to), tells of a cat which, having been taken to Mombas, "underwent a complete metamorphosis," and "parted with its sandy-coloured fur" after only eight weeks' residence there. In Paraguay, again, cats seem unable to become thoroughly feral as they do in other places, and as other European animals do in Paraguay.

§ 7. The domestic cat begins to be ready to reproduce by the end of the first year of her life, and she is prolific to her ninth. Her young are carried for fifty-five or fifty-six days, and she generally has five or six young at a birth, and sometimes eight or nine. In a wild state the cat brings forth at least twice a year, but the domestic cat will do so three or four times annually. The wild cat has only four or five young in a litter. The length of life which cats attain varies with individuals, and is a point difficult satisfactorily to ascertain. It seems probable that about twelve years is its ordinary limit, but in some cases the age of eighteen years may certainly be attained under favourable circumstances.

Though small quadrupeds and birds are their natural prey, cats are singularly fond of food which in a wild state they can never or but seldom attain, namely, cow's milk, and also fish. In spite also of the relative obtuseness of their sense of smell, they are said to show a marked preference for certain odours, a taste in harmony with that luxurious and ease-loving nature with which they are endowed.

§ 8. To know all about the history and habits of the cat, together with the peculiarities of form and colour of its various breeds, both wild and domestic, is not to have a scientific knowledge of the cat. To know the animal scientifically, we must be able to answer correctly the question "What is a cat?" But we cannot so answer this question unless we know both the main facts as to the animal considered in itself absolutely, and the various leading relations in which it stands to all other creatures.

"We understand a particular kind of animated being, when looking inwards we see how its parts constitute a system, and again looking outwards and around, how this system stands with regard to other types of organised existence." *

No object can be understood by itself. We comprehend anything the better, the more we know of other things distinct from but related to it.

The complete natural history of any animal, in the full and proper sense of the term, is its *Biology*. It is so because, though the study of any animal is of course mainly its *zoology*, yet fully to understand certain of its powers, and the conditions necessary for its existence, a side glance should be cast at the vegetable world also; and Biology is the term which denotes the science of all living creatures—both animals and plants—and there-

* Essays by James Martineau, Second Series, p. 417

ire embraces within it both *zoology* and *botany*. Moreover, Biology ot only includes these two subordinate sciences, but also the various quiries which refer to the relations which exist between their spective subject-matters.

Now, in the first place, the study of the cat, as of every living reature, may be followed up along two different lines of inquiry. ne of these refers to the structure of its body, the other refers to ie actions which its body performs; in other words, the animal ay be considered statically or dynamically.

Before, however, considering these two kinds of inquiry, and eing what subordinate inquiries they respectively include, it may e well to note that the cat's body is obviously a complex structure, onsisting of distinct parts, which are also obviously put to different ses, and reciprocally minister one to another. Thus, for example, ie limbs may more or less rapidly propel the body after prey which ie eyes guide the paws to grasp and bring to the teeth and jaws y which it is divided to pass into the interior of the trunk, to be here converted by the digestive organs into nutriment, by which he limbs, the eyes, the paws, the teeth and jaws, stomach, intes- ine, &c., are themselves supported and maintained in healthy vorking condition. This animal's body, then, is *a complex whole in chich all the parts are reciprocally ends and means;* and such is the lefinition of "*an* ORGANISM," wide as is the difference in complexity etween organisms, both animal and vegetable, of very different kinds.

§ 9. The organism with which we are occupied, the cat's body, may, as has been already said, be considered as to its structure and as to its actions. As to its structure it may be considered with respect to its size, shape, consistency, the number, form, and relative position of its various parts, and such study is called ANATOMY. The inquiry as to its form is called *Morphology*, and this inquiry may be directed to its larger parts and grosser structures or to its minute structure.

The various parts of the cat's body, such as its tongue, eyes, stomach, kidneys, &c., are termed "organs," and these are grouped together into different "sets" or "systems." Thus, *e.g.*, we have the alimentary system of organs made up of the mouth, œsophagus, stomach, and intestine—or alimentary tube—with the various organs, liver, pancreas, &c., which are directly connected with that tube. But every organ is made up of several different animal substances, variously blended, and differing in their minute or microscopic characters. The study of such minute structure—such microscopic anatomy—is termed *Histology*. Each of the various substances thus minutely differing, and which build up the organs of the body, is called a *tissue*, and Histology is, therefore, the science of the tissues of which every living creature may be composed. Histology enables us to understand the structure and nature of the ultimate substance or *parenchyma* of the body, as far as our powers of observa- tion at present extend; but those powers are very imperfect, and

are very far from enabling us really to understand the absolutely ultimate composition of the body.

Another science which concerns the structure of the body is *Comparative Anatomy*. By it the structure of the whole body or of any part of the body is compared with the bodies or corresponding parts of the bodies of other creatures. The comparative anatomy of animals is sometimes called Zootomy. The above inquiries all refer to the number, shape, arrangement, connexion and relative position of parts (whether large or minute), and to the resemblances and differences between different living creatures thus regarded.

The inquiries which constitute the next set of Biological sciences, refer to the *actions* which the cat's body performs.

Obviously the animal moves, takes food, and, if young, increases in size. The slightest observation convinces us that it has senses, feelings, and emotions, more or less similar to our own. If emaciated by starvation we see that it can by food regain its former bulk, and we may observe that trifling wounds or injuries may be repaired. Others of its actions normally result in the production of a new individual—another generation. In short the animal *lives*. These activities are, as we all know, shared by other animals, and some of them by plants also, which grow and repair certain injuries—replacing lost parts—and reproduce their kind.

§ 10. The term usually employed to denote the study of the bodily activities, or *functions* generally, is PHYSIOLOGY.

This study is made up of various subordinate inquiries. We may consider the functions of each tissue, of each organ, and of each system of organs. Thus we have, *e.g.*, the study of the actions of the system of organs which nourish and support the body: *i.e.*, the study of the function of *sustentation*. We have again the study of that system of organs which serves to continue the race, *i.e.*, the study of the function of *reproduction*.

We shall hereafter see that the former function is performed by various organs destined respectively to receive and digest food, to distribute about the body the nutritious matter obtained from it, to breathe and to form or secrete certain products. These functions, therefore, are those of (1) *alimentation*, (2) *circulation*, (3) *respiration*, and (4) *secretion*.

But a creature, such as our type the cat, not only lives and reproduces, it is also active, and executes a great number of apparently voluntary and other actions, and has a power of experiencing a variety of sensations. The functions then of (1) *motion*, and (2) *sensation*, form other subjects of physiological inquiry.

The last two functions are called *the animal functions*.* The functions which minister to sustentation and reproduction, as they are found in all living creatures, plants as well as animals, are called *the vegetative*, or *vegetal, functions*.

* Because sensation does not exist in any plant, while locomotion and all conspicuous powers of motion are special animal endowments.

Yet another and a somewhat peculiar study, is the study of *evelopment*. It is a study at once morphological and physiological. For it is the study of the changes which the animal passes through n proceeding from its first condition, as a germ, to its adult stage f existence. It is, therefore, a study of form and a study of an ctive process both together.

It is also desirable not only to note the function of each organ nd set of organs, but also to consider the activity of the animal as a whole—the *physiology of the individual* or *Psychology*.

§ 11. But we shall be quite unable to answer the question, What is a cat? if we do not learn the relations in which it stands to other living creatures—its position in the general scheme of things: in other words, the cat's place in nature.

We must therefore compare the cat with all other living creatures; but especially with those which resemble it the more nearly. But to do this we must first understand more or less what the general scheme of organic nature is, that is to say, we must learn something of the arrangement and classification of living beings, *i.e.*, of the science of *Taxonomy*.

§ 12. Every animal and plant (and therefore, the cat and the cat tribe) has certain definite relations to space and time. Its geographical distribution and its past history, as shown by fossil remains, also form indispensable matters of inquiry, and respectively pertain to the sciences of *Organic Geography* and *Palæontology*. But every living creature has also relations with other living creatures, which may tend to destroy it or indirectly to aid it, and the various physical forces and conditions exercise their several influences upon it. The study of all these complex relations to time, space, physical forces, other organisms, and to surrounding conditions generally, constitutes the science of *Hexicology*.*

§ 13. But there is yet one more inquiry, without which any modern work on zoology would be quite incomplete, and that is a genealogical investigation, the prosecution of which pertains to the science of *Phylogeny*. This science (assuming the truth of the doctrine of evolution)† investigates the evidence as to the various ancestral forms through which any now existing organism has probably passed in its descent from the most remote organisms which can, with any degree of probability, be regarded as its ancestors. We must then, finally, endeavour to gain what light we may as to the first origin of that form of life which has been chosen for study—in other words we must investigate the cat's probable pedigree.

§ 14. It appears to the writer that the study of the cat's anatomy and physiology may be best pursued by considering the function

* ἕξις—habit, state, or condition.

† The doctrine of evolution teaches that each existing kind of animal or plant was originally derived by a natural process of generation from other animals or plants more or less different in kind from it.

of each organ and set of organs, together with their structure, and to treat of them in the following order:—

I. The skeleton, both external and internal.
II. The parts which act upon the skeleton to effect motion—the muscles.
III. The organs of alimentation.
IV. The organs of circulation.
V. The organs of respiration and secretion.
VI. The generative organs and reproduction.
VII. The nervous system and organs of sense.
VIII. The development of the body.
IX. Psychology.

The facts of structure and function having been disposed of, we may proceed to consider the various affinities of the cat to other animals, its relations to space and time, and the question of its origin.

§ **15**. Before, however, commencing the proposed description, it may be well to state briefly a few facts as to the chemical composition of the body.

The body of the cat is chemically composed of four principal elements, namely, oxygen, hydrogen, nitrogen, and carbon, with small quantities of other elements—sulphur, phosphorus, chlorine, fluorine, silicon, potassium, sodium, calcium, iron, and magnesium. These elements are united together so as to form water, carbonate of lime, chlorides of sodium and potassium, sulphates and carbonates of soda and potash, phosphates and carbonates of magnesia, fluoride of calcium, and ammonia, and they are ultimately united into very complex groups of elements, termed "organic" compounds, the study of which pertains to a special science called *organic chemistry*. These very complex chemical groups of elements are called the *proximate elements* of the body because they are the first component substances into which it can be dissolved when in course of being reduced to its ultimate elements. Such proximate elements are grouped in two classes: 1. Those called *nitrogenous*, because containing nitrogen, and 2, the *non-nitrogenous*, because destitute of this element. Most of the component substances of the body, such, *e.g.* as the flesh and the blood, are composed of the first, or nitrogenous, proximate elements, of which the substance of the white of egg, called *albumen*, and that of jelly, called *gelatine*, form the types. Fats, on the contrary, are non-nitrogenous substances, and consist only of oxygen, hydrogen, and carbon, or if they contain other elements, nitrogen is not amongst them. The nitrogenous substances are also spoken of as *proteid*, because they have been supposed to be derived from an imaginary substance termed *protein*, consisting of oxygen, hydrogen, nitrogen, and carbon. They are also spoken of as forms of *protoplasm*.* About four-sevenths of the weight of the

* A term proposed by Mohl to denote the soft interior of cells. Every living creature is at first entirely composed of this quaternary compound.

nimal's body is made up by water, of which it is, therefore, very rgely composed, the brain containing about seventy per cent. of at fluid.

In saying that the body consists of different parts and substances, nd is made up of combinations of elements, all that is meant is nat it can be more or less readily divided into such parts, and that can be dissolved into such elements, just as water may be destroyed give place to oxygen and hydrogen. Whilst living, however, he body really forms *one continuous whole* locally differentiated, that s, assuming different appearances and possessing different properties n different regions. Even the very blood is directly continuous vith the other constituents of the body in all actively growing parts.

CHAPTER II.

THE CAT'S GENERAL FORM.—THE SKIN AND ITS APPENDAGES.

§ 1. THE cat's entire frame is divisible into head, neck, trunk, tail, and limbs, of which latter there are two pairs. Its body is everywhere more or less closely invested by a firm skin, nevertheless this is loosely attached in certain parts and so forms folds here and there, as *e.g.*, between the trunk and the elbow and knee respectively. Its skin is almost entirely clothed with hair, which is generally of moderate length, often being longer on the belly and tail than elsewhere; but the length of the hair varies, as we have seen, according to the breed to which different cats may belong. It is, however, always short on the paws and face. The hairs are directed backwards from the head to the tail, and, for the most part, downwards on the limbs. There are long hairs inside each ear and sometimes on its tip, and about a dozen very long and strong hairs—the whiskers or *vibrissæ*—are placed on each upper lip. There are also a few long hairs over each eye, or eyebrows, but there are no eyelashes. The end of the nose, the lips, and the skin of the fleshy pads beneath the paws, are naked.

FIG. 1.—CAT'S MUZZLE, SHOWING VIBRISSÆ AND NAKED SKIN ABOUT THE NOSTRILS.

he head is rounded, and the jaws are rather short. The eyes large, and separated by a considerable interval. The ears me narrow as they ascend, and each stands with its deep cavity directed forwards and outwards. The neck is a little rter and less voluminous than the head. The front limbs are rter than the hind limbs, and consist each of an upper arm, a -arm, and a paw with five short toes. Each hind limb has a gh, a leg, and a foot with four toes. The proportions of the y are such that both the elbow and knee are placed close to trunk.

Certain symmetrical relations and contrasts between different parts the cat's frame are evident on even a cursory examination of it. us there is an obvious contrast between its dorsal and its ventral ect, and this contrast extends along each limb to the ends of the s.

Again, there is a resemblance (and at the same time a contrast) ween the right and left sides, which correspond with tolerable ctitude one to the other.

This harmony, termed *bilateral* symmetry, though obvious exter- ly, does not prevail in all the internal organs (viscera), which are re or less unsymmetrically disposed.

Thirdly, there is a resemblance and correspondence between parts ced successively, as, for example, between the arm and the leg, between the fore and hind paws; although this resemblance ss obvious than it might be, owing to the different directions which the knee and elbow are bent. Such a symmetry is termed *al*, and is thus even externally visible; but it becomes much re evident when the animal's internal structure is examined. ere we find many successive parts—like the ribs, or the pieces of backbone—which obviously resemble each other very closely, l so are called by a common name. Such parts are placed after another in a "series," and it is on this account that the ametry of which they are examples is called *serial symmetry*.

If we remove the cat's skin we see beneath it a mass of red flesh he muscles or organs of movement—and these are divided one n another by delicate membranes. If the muscles be cut away, come sooner or later to subjacent bones—those of the head, neck, nk, tail or limbs, as the case may be. The bones of the head, nk and tail, are the "skull, backbone and ribs."

If the trunk be cut open, it will be seen that a variety of organs eart, lungs, kidneys, stomach, intestines, liver, &c.—lie enclosed a cavity within it. If the skull and backbone be cut through, the ite substance of the brain and spinal marrow will be found within n. Delicate threads of a similar white substance, the *nerves*, (which ister to motion and feeling) traverse the body in all directions, lso do a multitude of tubes or vessels, which convey blood to or n the heart. The anterior part of the trunk-cavity (which tains the heart and lungs,) is divided from the hinder portion by eshy and membranous partition—the diaphragm. This partition

is traversed by large blood-vessels and by the alimentary tube, which extends continuously from the mouth backwards to its posterior termination. The parts of which the cat's body are composed are

Fig. 2.—Diagram representing a Vertical Section through the Cat's Body.

n. Brain and spinal marrow contained within the skull and backbone, which are deep black.
st. Breast-bone.
dd. Alimentary canal.
s. Stomach.
h. Heart.
cc. Great blood-vessels.
u. Urinary bladder.
sy. Chain of sympathetic ganglia.
di. Diaphragm.

thus conveniently divisible into the bones, with their membranes—the *skeleton;* the muscles; the nervous system and organs of sense the system of vessels, or circulatory system; the alimentary tube with its appendages; the lungs and kidneys, with certain other parts, and the organs of reproduction.

THE SKELETON.

§ **2.** The word "*skeleton*" is popularly taken to denote only the *bones*, with the *cartilage* or gristle which may be connected with them. It should, however, be taken to mean not only these but also the membranes, which radiating from the bones and cartilages invest every organ of the body, and finally clothe it externally in the form of "skin." Such membranes penetrate the very bones themselves and support the marrow they contain; they separate every muscle from its neighbour, and surround and line each tube and passage in the body; so that if every other tissue could be dissolved away and yet this fibrous tissue be left, we should have a complete outline model, as it were, of the cat's entire frame.

§ **3.** This substance, which is, as it were, the basis of the skeleton, is formed of what is called CONNECTIVE TISSUE, which consists of a mass of delicate white fibres imbedded in a structureless material or "ground substance;" scattered through this are minute particles of protoplasm, called "corpuscles," which are more or less rounded or

flattened in shape, sometimes giving off ramifying processes, which may unite with branches from neighbouring connective-tissue corpuscles. Within the corpuscle is a round or oval *nucleus*, which contains one or more *nucleoli*.* The structureless substance and fibres form what is called the *matrix* of the tissue, and the cor-

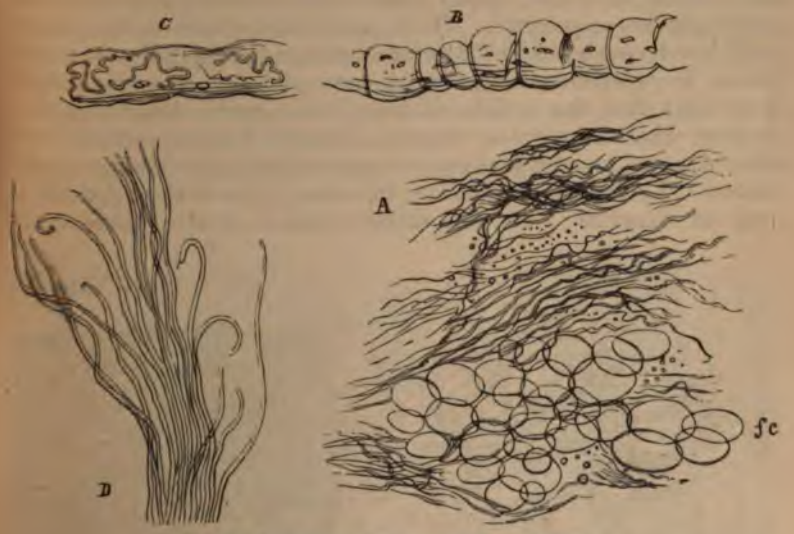


Fig. 3.—Connective, Adipose and Elastic Tissue.

A. Loose areolar tissue with fat cells.
fc. The fat cells.
B. and C. Magnified view of areolar tissue treated with acetic acid. The white fibres are here no longer seen, and the yellow or elastic fibres with the nuclei come into view. In Fig. B, a series of constrictions is produced by the presence of an elastic fibre, which is spirally disposed about the (here swollen and invisible) white fibres. The white fibres may be $\frac{1}{10000}$ of an inch in thickness or even less.
D. Fibres of yellow or elastic tissue.

puscles are cells which are thus more or less plentifully distributed within the matrix.

Intermixed with the ordinary fibres may be others of a yellower colour (and with a different chemical reaction), known as "elastic fibres," or "*elastic tissue*." These fibres may be rendered conspicuous under the microscope by the addition of acetic acid, which causes the white fibres to swell and become indistinct, thus revealing the existence of the unaffected yellow ones.

* It may be well to remind the reader that the body of every animal, and therefore of the cat, consists at first of a single "*cell*," or minute particle of protoplasm, and afterwards, for a time, of an aggregation of such cells whence all the tissues of the body are ultimately derived, and which in different degrees preserve traces of their cellular origin. Cells commonly contain a modified internal part or parts called a *nucleus* or *nuclei*, when they are said to be "nucleated." It is very common for the nucleus to again contain a more minute internal particle, termed a "*nucleolus*," or it may have several *nucleoli*. Thus, the connective-tissue corpuscles are "nucleated cells."

Certain portions of connective tissue which connect adjacent bones or cartilages become very strong, and constitute the *ligaments*. These are flattened or rounded bands, formed of straight, parallel fibres and are very dense in structure, with corpuscles elongated in the direction of the fibres.

Other fibrous structures are the membranes which closely invest the bones or cartilages, which membranes are called *periosteum* and *perichondrium* respectively. These are formed of intersecting fibres, with blood-vessels, which latter are destined to supply the structures which the membranes invest. A more delicate connective tissue penetrates into the cavities of many bones, and is loaded with fat, forming what is known as *marrow*. Fat, or "adipose tissue," consists of round or oval vesicles (or minute bags), containing an oily matter. The vesicles are mostly from the $\frac{1}{300}$th to the $\frac{1}{800}$th of an inch in diameter. In the earliest period of its existence the

Fig. 4.—Cat's Cartilage, greatly magnified.

a. Fibro-cartilage. b. Hyaline cartilage, showing the nucleated cells enclosed in the capsules.

skeleton consists entirely of connective tissue, but becomes largely transformed into bone—*i.e.*, it *ossifies*—by the deposition of calcareous salts around the blood-vessels, which advance and invade the tissue about to ossify.

§ 4. Cartilage, is an opaque, firm but highly elastic substance, generally of a bluish-white colour. Like connective tissue it consists of a matrix, and this contains very distinct cells. The matrix, however, is generally homogeneous. Such is *hyaline cartilage*. Certain cartilage, however, contains fibres, and is therefore called *fibro-cartilage*, and if it contains elastic tissue also, it is known as *yellow fibro-cartilage*. The cells are inclosed, either singly or in groups, in rounded, unbranched hollows termed *capsules*, the walls of which may be somewhat denser than the rest of the matrix. Cartilage

does not contain blood-vessels, but can yet grow rapidly, the nuclei of the cells multiplying and the cells and corpuscles themselves enlarging and dividing—the homogeneous matrix coming to occupy the intervening space as the capsules divide and separate.

§ 5. BONE, or osseous tissue, is a substance, two-thirds of which, in the cat, consists of mineral matter—namely, of phosphate with some carbonate of lime, and a very little fluoride of calcium, phosphate of magnesia and common salt. The animal * and mineral parts are absolutely united, since by the elimination of either, the shape of the bone remains unaltered.

Compact bone, such as that which forms the thigh-bone of the cat, exhibits on its surface a number of microscopic holes, which are the external apertures of canals, called "*Haversian*," which thence

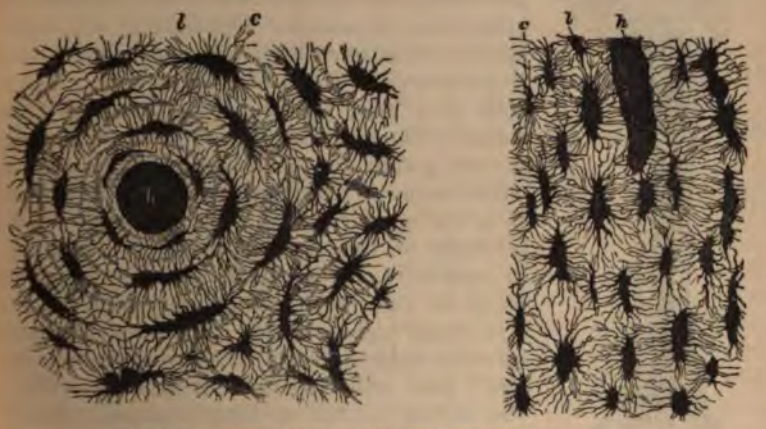


FIG. 5.—SECTIONS OF CAT'S LEG-BONE, GREATLY MAGNIFIED.

The right-hand figure shows the layers arranged concentrically around the Haversian canal. The left-hand figure shows a section nearly in the plane of such a canal.

h. Haversian canal.
l. Lacunæ.
c. Canaliculi.

enter and ramify. These holes and canals serve to admit blood-vessels. The bony substance forms concentric layers about such canals, while the layers themselves contain a number of irregular radiating spots, which are also arranged in concentric rings corresponding with the layers in which they lie. These spots are interspaces called "lacunæ," (and sometimes "bone corpuscles,") and their outline is so irregular because each gives off a number of minute tubular processes, termed *canaliculi*. The canaliculi of

* This substance when boiled yields *gelatine*. Cartilage yields *chondrin*, which differs somewhat from gelatine in its chemical relations; but, like it, dissolves in hot water, and forms a jelly on cooling. Connective tissue also yields gelatine when boiled, but elastic tissue does not. The latter tissue is also (as before said) unaffected by acetic acid.

adjacent lacunæ unite, and thus fluid can traverse every part of the bone.

The Haversian canals grow larger as they proceed inwards (in such a bone as that of the thigh,) and open into still larger channels and yet wider interspaces which are called *cancelli*, ultimately merging into a hollow central part called the *medullary cavity* of the bone because it contains that delicate fibrous tissue and fat which constitutes marrow, as already mentioned.

Some bones have their entire substance replete with cavities or cancelli, and such are called *cancellated* or spongy.

§ 6. OSSIFICATION may take place either through pre-existing cartilage or through membrane, and in either case blood-vessels advance into the pre-existing material, and therewith that material is absorbed and disappears around them and is replaced by calcareous substance. The lacunæ are interspaces which have been left uncalcified owing to the presence there of certain cells. These cells have sent out radiating processes (like some of the connective-tissue cells, as already noticed,) which have also escaped the general calcification of the intercellular substance, and thus the canaliculi have been produced. Thus contents of the lacunæ are truly bone-cells or corpuscles. Bone tissue therefore is, except as to its calcareous nature, very like connective tissue and cartilage. The bony substance answers to the matrix of these other tissues, and the "bone cells" to their corpuscles. When the earthy matter of bone is dissolved their original cellular contents may often be detected.

Fig. 6.—VERTICAL SECTION OF CAT'S THIGH-BONE (FEMUR). Showing its epiphyses of the head of the bone (*he*), the great trochanter (*te*), and of its distal end (*ie*).

When a bone ossifies from cartilage, as all thick bones do, the deposit begins in the form of opaque granules of calcareous matter, which surround and sometimes invade the cartilage capsules and form a dense and irregular osseous tissue, without lacunæ or canaliculi. Spaces are then formed in this substance by absorption, and if these spaces largely accumulate, cancellated tissue is formed. The spaces may, however, become filled with a fresh and secondary deposit of bone in concentric rings round the blood-vessels, thus forming the "compact bone" already described.

When bone is formed from membrane, it assumes the compact form, with lacunæ and canaliculi, at once, and is not preceded by granular deposit.

§ 7. The GROWTH OF BONE takes place in various ways by the ossification of the inner layer of the periosteum surrounding it. In long bones, which are preceded by cartilage, the ends remain for some

time cartilaginous. These cartilaginous ends ossify subsequently, but long continue distinct from the median part and are called *epiphyses* (Fig. 6), which only unite with the rest of the bone when the animal has attained maturity. Epiphyses are often developed at the ends of any projecting pieces of bone or "processes."

A bone may thus be developed from more than one point, *i. e.*, from several "centres of ossification," the respective growths from which ultimately unite to form one whole. A continuation of the same process may fuse together even entire bones which have for a time remained separate and distinct.

The most external layer of the skin consists of yet another substance, which is known as *epithelial tissue*, and which is very distinct in nature from connective tissue or the elastic cartilaginous or osseous modifications of connective tissue.

§ 8. Such are the substances or tissues of which the cat's skeleton is in its entirety composed.

That skeleton is naturally divisible into two parts:

(*a.*) The external, peripheral skeleton, often called the EXO-SKELETON—the skin and its appendages.

(*b.*) The internal central skeleton, often termed the ENDO-SKELETON.

§ 9. The EXTERNAL SKELETON of the cat is made up of its skin, with the hair which coats it, the claws, and also the teeth. No cartilage or true bone enters into its composition.

The skin of the cat, like our own skin, consists of TWO LAYERS: an external layer, devoid of nerves and blood-vessels (and consequently of feeling), and a deeper layer, which is supplied with both nerves and blood-vessels, and is highly sensitive. The external layer is called the *epidermis*, the deep layer is called the *dermis*. At the lips the external layer visibly changes in texture, and inside the lips and mouth it becomes soft and moist, and is termed *mucous membrane*. This, however, is a mere modified continuation of the external skin. The superficial layer of inwardly reflected skin is termed the *epithelium*, which is thus but a modified epidermis, and the common term ECTERON is applied to both epidermis and epithelium, as the term ENDERON is applied to the deeper or dermal layer (*i. e.*, the dermis) wherever situate.

§ 10. The *Epidermis* is an EPITHELIAL TISSUE, and consists of numerous superimposed layers of epithelial cells, of which those near the surface are flattened into scales, while the deeper ones are more and more rounded, the deepest even assuming a vertically elongated form. As the epidermis is worn away from the surface in minute fragments, newer cells rise successively from below (to replace those lost) from a layer of structureless substance which connects the epidermis with the subjacent dermis. In this layer minute particles (*nuclei*) arise and gather round them spheroidal portions of the substance itself, thus forming cells which subsequently multiply by spontaneous division or fission, the process commencing with the division of the nucleus of each cell. The deeper strata of epidermis contain

the colouring matter of the skin, and are often considered as forming a distinct part called the *rete mucosum*. The superficial or older layers acquire a horny nature. The surface of the epidermis exhibits numerous minute orifices of sweat-glands—the pores—and, especially on the paws, numerous minute ridges.

§ 11. The DERMIS, or *corium*, is a form of connective tissue. Its upper surface is almost free from fibres, but beneath, these first grow abundant and then begin to leave larger and larger interspaces, till the fibrous tissue becomes what is called "*areolar*," and so forms the substance connecting the skin with the subjacent structures, *i.e.*, it forms that white, filmy substance which is broken through when the animal is skinned. In the deeper portion of the true skin there are curled yellow fibres of elastic tissue, and there may be some or many muscular fibres. Its outer surface is drawn out into little prominences or papillæ arranged in close-set parallel rows (especially on the paws), which occasion the ridges above mentioned, or existing in the superimposed epidermis. Many of these papillæ contain nerves and blood-vessels, the former ending in a fine coil about a minute ball or core of nucleated tissue, thus forming what are called "axile bodies," or "touch corpuscles" (Fig. 7, B).

Sweat-glands consist of minute tubes, each opening at the surface at a "pore," whence it descends into the skin and passes through it into the loose connective or areolar tissue beneath it, where it ends in a coil surrounded by minute blood-vessels. The meshes of the loose subcutaneous tissue contain fat, which, as before mentioned, is enclosed in minute bags of membrane. It is fluid during the life of the animal, and both helps to keep the body warm (being a bad conductor of heat) and serves as a store of nutriment. Other structures called *Pacinian bodies* are found in some parts of the skin of the body—notably in a membrane (the mesentery) which invests part of the bowels. Each such body consists of a number of layers of membrane, with fluid interposed, and with a central space into which a nerve enters (Fig. 7, A).

§ 12. The CLAWS, of which there are five to each fore-paw, and four to each hind-paw, are special thickenings of epidermis, and are (like the outer layer of epidermis generally) horny. But the dermis is also specially modified with a view to the formation of the claws; for at the root of each claw it forms a transverse crescentic fold over it, while beneath the claw, it is produced into a number of close-set rows of papillæ richly supplied with blood-vessels—forming what is called the *matrix* of the claw. From its surface, and also within the crescentic fold, fresh epidermal cells are continually formed, which rapidly become harder, and cohere to form the claw, the root part of which is soft, like the deeper layer of epidermis, with which layer it is directly continuous. The claws are placed around the terminal part of the last bone of each toe, completely investing it, and ending in a sharp point.

§ 13. The HAIRS each consist of a root, fixed in the skin, and the shaft, or stem, which may be cylindrical, or flattened. Each hair is

formed, like each claw, of modified epidermal cells, but then each hair grows from a single dermal papilla only, of which it is the greatly prolonged epidermal covering. Moreover, this dermal papilla does not stand up from the surface of the dermis, but is placed at the

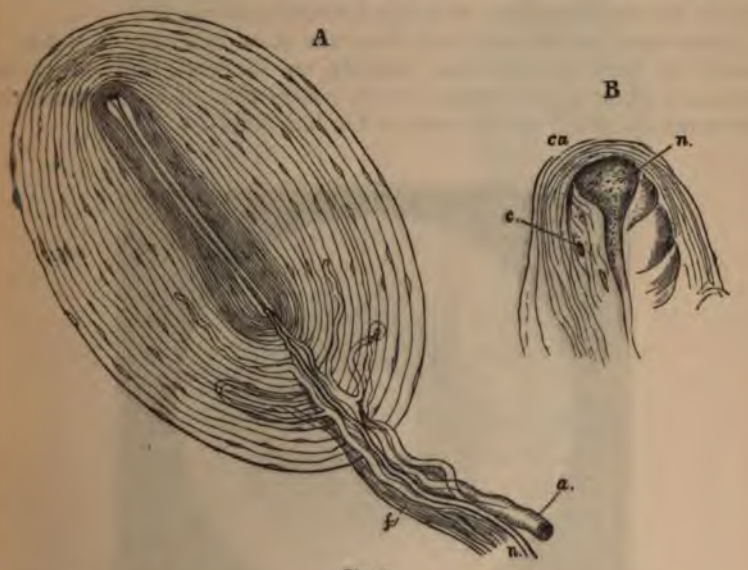


Fig. 7.

A. PACINIAN BODY FROM CAT'S MESENTERY.
a. Artery.
n. Nerve.
f. Fibrous tissue.

B. TOUCH-CORPUSCLE.
ca. Epithelium.
c. Nuclei.
n. Core, into which the nerve enters.

bottom of a small sac, the *follicle*, which is a depression in the cutis. The central part of the hair, or *pith*, is less dense than its rind, or cortical substance, which is formed of very long, horny cells which have coalesced. Outermost of all is the cuticle or epithelial layer, formed of very thin overlapping scales. The colouring matter is deposited within the outermost layer, and may be uniform throughout, or may be different in different parts of the same hair. Some hairs are especially slender, and have the edges of the scales of their cuticle so projecting, as to form a serrated envelope. Such hairs are "wool," and easily become entangled and adherent together by their serrations, or "felted." True hair, such as the cat's, has not the property of "felting," because its surface is smooth.

Although hairs (like claws, and the epidermis generally) have no blood-vessels, yet the sudden changes which may sometimes take place in their colour, prove that nutritive modifications extend into them.

Very small vessels pass into the papillæ of the hairs, which are also furnished with a minute nerve, to the presence of which the pain felt when the hair is pulled out is due.

The root, or bulb, of each hair consists of the dermal sac with its enclosed papilla and the epidermal formation which lines the sac and invests the papilla. It is considerably larger than the diameter of the hair it developes.

The cat's whiskers are simply hairs of great size, the bulbs of which are well furnished with blood-vessels and nerves.

Hairs are inserted obliquely into the skin, but can be made to stand up, or "on end"—as notably on the cat's tail when the animal is enraged—by means of the contraction of small muscular fibres which pass from the skin to the hair-bulbs.

Fig. 8.—Transverse Section of a Cat's Whisker, greatly magnified.

c. Cortical substance. | *m*. Pith or medulla.

Certain accessory structures are called *sebaceous glands*. These are minute flask-shaped bags (secreting an oily substance), which open into the upper part of the hair follicles, and so serve to lubricate the hair.

New hairs are formed by the budding off of a new papilla and follicle from beside those first developed, and by the growth of a cluster of epidermic cells at the bottom of the new follicle. Neither the new nor the older follicles are really formed by an actual inflection of the skin, though when completed they appear as if they had been so formed. Minute blood-vessels and nerves enter the roots of hairs, but do not extend beyond the dermal papilla.

§ **14**. Such are the appendages and such is the nature of the skin which clothes the cat's body externally, and which varies in thickness in different regions, being very thin on the lips, ears, and eyelids, thicker on the back and outer sides of the limbs than on the belly, and especially thick upon the pads of the feet on which the animal walks. Of these there are seven in the fore paw, and five in the

hind paw. Each pad consists of a mass of fibrous tissue and fat, and a large trilobed one is placed beneath the ends of those bones on which the animal rests in walking, as represented in the figure here

Fig. 9.—Under Surface of Fore-paw.
I, II, III, IV, V. The five toes, I being the pollex.
a. Trilobed pad which lies beneath the distal ends of the metacarpal bones.
* Pad beneath the pisiform bone of the wrist.

Fig. 11.—Columnar ciliated Epithelial Cells, magnified 300 diameters.
A number of cilia are seen on the flattened superficial end of each cell, which also contains a nucleus with a nucleolus.

Fig. 10.—Under Surface of Hind-paw.
II, III, IV, and V. The respective four digits.
a. Pad beneath the metatarsal bones.
h. Heel.

given. But, as before observed, the skin does not clothe the exterior of its body only; at the margin of the lips it is reflected inwards, lining the mouth and continuing on to line the whole alimentary canal, and it also lines all the other passages which open on the exterior of the body. The cat's body may thus be compared with a ring-shaped air-cushion which has been very much drawn out on each surface, the central vacant space being also greatly prolonged, but contracted in diameter to represent the alimentary canal.

Thus the real body of the animal lies enclosed between the external skin and its internal reflected continuation, and answers to the enclosed interior of the ring-like air-cushion. A real "body cavity" is therefore not the inside of the alimentary canal, or the inside of any other passage opening on the exterior; all such passages being of course but so many continuations inwards of external space. A real "body cavity" would be any cavity existing enclosed between the external skin and its internal reflected continuation. This reflected skin is soft and delicate, with a moistened surface, and is called "*mucous membrane*." Such membrane lines two great sets of organs. One of these is the *gastro-pulmonary* mucous membrane, and lines the mouth and alimentary canal, the eyelids, ears, nostrils, cavities in the skull, and the windpipe and lungs. The other is called the *genito-urinary*, and lines the bladder and the parts connected with its passage outwards.

§ 15. Just as the external skin consists of epidermis and dermis, so its reflected portion consists of a non-vascular *epithelium*, with a subjacent highly vascular *corium*, which often contains much muscular fibre. Between them is the homogeneous structureless layer termed the basement membrane. The component cells of the epithelium may be elongated at right angles to the basement membrane, thus forming what is called "*columnar epithelium*" (as in the stomach and intestine), or they may be rounded, forming *spheroidal epithelium*, as in the lining of the ducts of the "glands" * of the alimentary canal.

Sometimes parts of the substance of epithelial cells may protrude as thread-like processes or *cilia*, which are capable of performing repeatedly a whipping-like movement. A membrane consisting of such cells is called *ciliated epithelium* (Fig. 11), and such we shall find in certain of the cat's alimentary and respiratory organs, in the description of which † this kind of tissue will be again noticed.

The *corium* contains yellow (or elastic) as well as white fibres, and the supply of either may be copious or scanty. Its surface may be even or very uneven. Thus it may be produced into many, often relatively large, papillæ or *villi*—scattered or closely set—or into ridges which may so intersect as to form polygonal pits between them.

Just as the outer skin is furnished with sweat and sebaceous glands, so also mucous membrane is copiously furnished with small glands which have different functions in different parts; but a generally diffused secretion, called *mucus*, is formed by them, which gives its name to the membrane in which its formative glands are imbedded. It is slightly alkaline, and serves to preserve the moisture of the surfaces it lubricates, as well as to protect them from the dissolving action of fluids secreted to dissolve and digest food temporarily held within cavities (the stomach &c.) which are lined by mucous membrane.

* Epithelial cells may, as we shall hereafter see, take on the function of manufacturing some special product or "secretion." Parts which thus act are termed "glands."

† See below, Chapter VI.

The mucous membrane is connected with the subjacent parts by *submucous* areolar tissue, which is often lax, so that the mucous membrane, when not stretched, is thrown into effaceable folds or *rugæ*. It may also form folds which are not to be effaced by any stretching of the skin, as, *e.g.*, on the palate (Fig. 86).

The membrane lining the mouth abounds in small glands, those within the cheeks and lips being termed *buccal* and *labial* respectively.

§ **16**. The mucous membrane of the mouth has certain calcareous appendages—the TEETH—which are mainly calcifications of the corium, but in part are ecteronic—or calcifications of the epithelium—so that the nature of each is compound.

The teeth are not only parts of the external skeleton, but are

FIG. 12.—THE TEETH OF THE RIGHT SIDE OF A CAT'S MOUTH, SEEN ON THEIR INNER SURFACES.

i. Incisors.
c. Canines.
pm. Premolars.
m. Two molars. (The outer aspect of the teeth is shown in Fig. 46. See also Fig. 29.)

closely related to the internal skeleton also, since they are implanted in special sockets—or *alveoli*—provided for them in the margins of the jawbones, which margins are on that account spoken of as "alveolar." The part of each tooth which is thus implanted is its "fang." The part which appears above the surface of the mucous membrane is called the "crown," and the line of junction is the *cervix*, or *neck*. Each alveolus closely invests the fang contained within it. Most of the teeth have but a single fang, which tapers as it penetrates its alveolus; but there may be two or three fangs to a single tooth.

The teeth of the cat, when adult, should be thirty in number. Those of the two sides of each jaw are alike, but those of the upper jaw differ from those of the lower jaw.

The three front teeth of each lateral half of the upper jaw are very small and simple in shape. They stand side by side, so that

they form (with their three fellows of the opposite side) a row of six teeth arranged in the same transverse line. Each tooth has a single, conical fang. The first, or innermost—of the three teeth of this kind on each side—is the smallest, and the outermost considerably the largest. The innermost, when quite unworn, has its crown indented by a transverse furrow, while the part anterior to the furrow is produced into three points or cusps, whereof the middle one is the largest. The next tooth is similar, save that the outermost of the three cusps is larger and the innermost one smaller than in the tooth first described. In the third tooth there is no innermost cusp, and the outer one is much smaller, while the inner one (corresponding with the middle cusp of the two preceding teeth) is very much larger, forming almost all the crown of the tooth. This is the condition of these teeth only when quite unworn; very soon there can only be distinguished a slight transverse posteriorly placed furrow, with a prominence in front of it, which is more or less irregular in outline. These three teeth are called *incisors*, and thus there are altogether six incisors in the upper jaw.

The next tooth, which is separated from the outermost incisor by a considerable interval or *diastema*, is a very large, strong conical tooth called a *canine*, with a fang generally much thicker and larger than its crown. The crown is somewhat curved, and is sharply pointed with a strongly marked vertical groove on its outer surface, and a less marked groove on the surface which is turned towards the inside of the mouth. On its hinder margin is a more or less distinct vertical ridge.

The next tooth (separated from the canine by an interspace) is a very small one, and, like the two which come behind it, is called a *premolar*. It has an obtuse conical crown with a single fang.

The next tooth, or second premolar, is very much larger, and has two diverging fangs, one in front of the other. Its crown is compressed or flattened from within outwards, and consists of one large triangular pointed cusp, at the base of which there is in front a small single tubercle, while, posteriorly, there are two small ones juxtaposed, one behind the other. The third premolar is yet larger—the largest of all the cat's teeth—and from its trenchant shape (so well adapted to cut flesh) is called the upper *sectorial* tooth. It has three fangs, two smaller in front (placed one within the other on the same transverse line) and one much larger, placed posteriorly.

Its crown consists of three external lobes (or cusps), separated by two notches, and of one internal tubercle. Of the external cusps the first is the smallest, and the second, which is backwardly directed, is the largest. A ridge from the first and second extends inwards to meet at the internal tubercle (Fig. 29), which projects downwards but little. A very slight horizontal prominence or ridge (the external *cingulum*) connects the bases of the three external cusps on the outer surface of the tooth. When this tooth is viewed from within, a sharp ridge is seen to connect the middle and hindmost of the external lobes, forming a very cutting blade, deeply

otched at its middle. Behind the third premolar is an exceedingly small tooth, which is called a *true molar*. It has two small fangs and a flattened crown, the greatest breadth of which (Fig. 86) is from without inwards. The common term *molars* is often used to denote all the teeth which are neither incisors nor canines; it being sometimes convenient to speak of such teeth as one whole, without distinguishing between premolars and true molars. In the lower jaw, at its anterior end, there is also a transverse row of six small incisors. The three of each half of the jaw increase in size from within outwards, as do those of the upper jaw; but they are all smaller than the upper incisors, especially the third, or posterior, one, which is not conical, like the corresponding tooth above. Then comes, without any interspace, a large, strong, pointed canine, so placed as (when the jaws are closed) to bite in front of the upper canine, passing up in the interspace between the upper incisors and canines. The lower canine resembles the upper canine in shape, save that it is somewhat shorter and more curved—its anterior and posterior margins being rather strongly convex and concave respectively. Next to the lower canine follow two premolars and one molar, separated however from the canine by a wide diastema. The first premolar corresponds with the second upper premolar, and bites in front of the latter. It has two fangs, while its crown (like that of its analogue above) has one large central lobe, at the base of which are two small cusps behind, with one in front.

The second premolar has also two fangs, and is like its predecessor, save that it is larger. The lower molar is very unlike the upper one, having a more completely trenchant form than any other tooth. It is called the lower *sectorial* tooth. It has two fangs, whereof the anterior is much the larger. Its crown consists of two nearly equal lobes, each ending in a point, the points diverging. At the base of the hinder side of the hinder lobe there is a minute, scarcely perceptible, indication of a posterior tubercle or "talon." On its inner side, the crown is deeply excavated between the lobes; but externally the surface is equably convex, save that a fissure descends vertically from the apex of the notch dividing the two lobes. The adjacent edges of each lobe are very sharp, so that the tooth presents an exceedingly trenchant margin, which bites against the similarly trenchant cutting edge above described as connecting the middle and hindmost external lobes of the upper sectorial. Thus these two trenchant margins act together like two blades of a pair of ivory scissors.

§ 17. The teeth of the adult cat are preceded by a somewhat different set, forming its milk-teeth or deciduous dentition. There are on each side of the upper jaw three deciduous incisors, one deciduous canine and three deciduous molars, and the same on each side of the lower jaw, save that there is one deciduous molar less. There are thus twenty-six milk-teeth in all. The deciduous incisors appear when the kitten is between two and three weeks old, then follow the canines and molars, all appearing by the end of the sixth

week. They begin to fall out after the seventh month, but the lower true molar comes into its place before the deciduous molars fall out. In shape the upper incisors are like their permanent successors, save that the transverse furrow is less marked. The upper canines are smaller and less grooved than the permanent ones.

The first upper deciduous molar is a small, simple one-fanged tooth like its vertical successor. The second deciduous molar is quite unlike the tooth which replaces it, but nearly resembles the third upper premolar or sectorial. Its outer cutting part, or blade, is three-lobed, but both the anterior and posterior lobes are notched, and the internal tubercle, which is relatively larger than in the permanent sectorial, is continued from the base of the middle lobe. There are three fangs, but the inner fang is more opposite the interspace between the two outer fangs than is the case in the true or permanent sectorial.

Fig. 13.—THE CAT'S MILK DENTITION, ENLARGED.

Below, the true molar is seen much advanced, and soon to rise behind the second lower deciduous molar. In the upper jaw the permanent upper sectorial is seen in an advanced state of development above the third deciduous molar.

The third upper deciduous molar is again quite different from the tooth which succeeds it, while it resembles the true or tubercular molar of the upper jaw, save that its relative size is larger.

The first deciduous lower molar is like the second premolar, while the second deciduous molar is like the inferior sectorial, with a relatively smaller anterior lobe and a much larger posterior tubercle, or talon, which is notched so as to form two small posterior tubercles at the base behind the posterior and greater lobe.

§ **18**. Such being the dentition (*i.e.* tooth-furniture) of the cat, it may be conveniently expressed by the following symbols:—

$I\frac{3}{3}$ $C\frac{1}{1}$ $PM\frac{3}{2}$ $M\frac{1}{1}$ for the second, or permanent dentition. $I\frac{3}{3}$ means "three incisors, above and below, on each side of the jaws;" $C\frac{1}{1}$ means similarly, "one canine on each side of each jaw;" $PM\frac{3}{3}$ means "three premolars on each side of the upper jaw and two on each side of the lower jaw;" and $M\frac{1}{1}$ means "one true molar both above and below on each side." Similarly, the symbols $DI\frac{3}{3}$, $DC\frac{1}{1}$, $DM\frac{3}{2}$ for the milk dentition, refer in the same manner to the deciduous incisors, canines, and molars respectively.

It need hardly be added that each tooth attains its full development within a limited time, after which it grows no more, and no third development ever replaces the fall of a tooth of the permanent dentition.

§ **19.** The SUBSTANCE of each tooth consists of a dense tissue of three kinds, called (1) *Dentine*, (2) *Enamel*, and (3) *Cement*, investing a small soft and sensitive mass called the *pulp*. The great body of each tooth is formed of dentine, and it is this which immediately surrounds the pulp. The cement coats the fang of each tooth only, while its crown is invested with a covering of enamel, which is the hardest kind of tooth substance.

The pulp consists of areolar tissue with cells and nuclei, and is in fact a modified portion of the corium—a large dermal papilla. It is highly vascular, and supplied with a nerve also.

Dentine is an animal substance impregnated with 72 per cent. of earthy matter, of which nearly 67 per cent. is phosphate of lime.

Fig. 14.—TOOTH SUBSTANCES.

A. Vertical section of second upper premolar. B. Horizontal section of right upper sectorial. | *d.* Dentine. *c.* Cement. *e.* Enamel. *pc.* Pulp cavity.

Instead, however, of presenting the lacunæ and canaliculi of ordinary osseous tissue, dentine only exhibits a number (but an enormous number) of very minute and very close-set tubes, which radiate from the wall of the pulp cavity on every side and with slight undulations; they become smaller towards the outer part of each tooth, while at their inner ends their diameter is about the $\frac{1}{4500}$ of an inch. Each tube, as it proceeds, gives off exceedingly minute branches, which appear to anastomose, and the tubules end distally by forming loops or by opening into minute cavities (dentinal cells) which are disposed around the dentine close to its surface, forming what is called its granular layer.

The greater part of the earthy matter is contained in the matrix, between the tubules, which do not in fact proceed from the pulp, but advance upon it, the outermost layer being that first calcified.

The *Cement* closely resembles bone, since it contains both lacunæ

and canaliculi. It is thinnest towards the cervix of each tooth, and thickens towards the apex of each fang, and there it may even contain vascular canals like the Haversian canals of bone tissue.*

The *Enamel* is so mineralized a structure that it only contains about 3½ per cent. of animal matter, while it has 90 per cent. of phosphate of lime. It consists of a multitude of slender, solid, undulating, hexagonal rods, closely adjusted to each other, and about $\frac{1}{5000}$ of an inch in diameter. Each rod is attached by one end to a minute depression of the surface of the dentine, and thence extends outwards, its distal part being at right angles to the external surface of the enamel.

Fig. 15.—THIN SECTION OF THE ENAMEL AND A PART OF THE DENTINE, 300 DIAMETERS.

a. External surface.
b. The rods or solid, six-sided prisms.
d. Tubuli of the dentine.
c. Clefts which occasionally exist in the deep part of the enamel.

§ **20.** We have seen that hair and claws are epidermic dermal appendages, but teeth are appendages of the dermis. They are not altogether so, however; for though the dentine is formed by ossification of a process of the corium, and cement by calcification of the connective tissue surrounding that papilla, yet the enamel has a different, and indeed an epidermal origin. It is formed from a depression of the epithelium of the gum, which dips in till it becomes applied to the apex of the rising dermal papilla, which last is destined, by its calcification, to form the bulk of the tooth. Having thus applied itself to invest the crown of the nascent tooth, it calcifies and so becomes the enamel.

Thus each tooth has a double nature. By its dentine and cement it is dermal, but its enamel is a modification of the epidermis.

Each permanent tooth takes its origin in a cavity of the jaw, placed just behind the milk-tooth it is destined to succeed. A little process from the inflected epithelium (or "enamel organ") which forms the enamel of the milk-tooth, is given off to invest the minute papilla which is to grow into the permanent tooth. As the new tooth is formed it rises in the gum, the space intervening between it and its successor becoming richly supplied with blood-vessels. The substance of the milk-tooth then becomes

* A substance called *osteo-dentine* is sometimes produced by the ossification of the pulp itself. It has vascular quasi Haversian canals, surrounded by concentric lamellæ, and is so far like bone. On the other hand, tubuli radiate from these canals, which tubuli are larger than the canaliculi of bone.

dly absorbed away by the aid of the blood-vessels—first the ent, then the dentine, and even part of the enamel—till what is becomes loosened and falls out. As the new tooth rises into the e of its predecessor, the bone of the jaw becomes simultaneously ified by absorption and redeposition, so as accurately to fit its ;—a striking example of that wonderful power of harmonious spontaneous modification which pervades the living body.

CHAPTER III.

THE SKELETON OF THE HEAD AND TRUNK.

§ 1. THE internal skeleton, or endoskeleton, of the cat is made up of numerous bones with cartilages and fibrous structures.

The number and nature of the parts vary with age. In the earlier stages of existence the cat has no bones at all, but ossification having once begun, goes on for a time energetically till maturity is attained; and, indeed, to a certain extent ossification goes on throughout life.

In this way it comes about that parts which are membranous in the kitten, or cartilaginous in the young cat, become bony in the full-grown animal. A continuation of the same process tends to unite bones which at their first appearance were separate. This process of union of bone with bone is called *anchylosis*. The hard parts of the internal skeleton being those which act as a framework support the body, form points of attachment for the muscles which move it; the muscles employing the different bones like so many levers or fulcra, as the case may be.

The great majority of bones being thus intended to move one upon another, certain parts of their surfaces are specially modified for mutual adjustment and motion, *i.e.* the contiguous surfaces of such movable bones form JOINTS.

These modifications will appear, as the forms of the bones are successively noticed; but the nature and mechanism of all the different kinds of joint will be more conveniently considered together after the skeleton has been described, immediately before studying the moving organs themselves.

§ 2. The parts which compose the internal skeleton may obviously be grouped into two divisions:—

(*a*). The skeleton of the head, trunk, and tail, which is called the AXIAL skeleton.

(*b*). The skeleton of the limbs, which is called the APPENDICULAR SKELETON, the limbs being regarded as appendages of the axial part of the body.

THE AXIAL SKELETON.

The axial skeleton is further conveniently divisible into the skeleton of the back, or *spinal skeleton*,—consisting of what is

miliarly known as the backbone, ribs and breastbone—and the eleton of the head, or *cranial skeleton*.

THE SPINAL SKELETON.

As has been said, this consists of the backbone, together with certain rches, the ribs, which extend from each side of a certain portion of he backbone downwards to or towards the breastbone or sternum.

§ 3. The backbone, or, as it is often called, the *spine* or spinal olumn, consists of a number of small bones placed one behind the ther, like a series of counters. Each of these small bones is called a VERTEBRA, and (with certain few exceptions, to be considered later) consists of a bony arch projecting upwards from a solid disk—the counter-like portion of the bone. Each whole vertebra may thus be described as a ring much expanded at one part, which is the lower part, and with certain bony prominences, which stand out from the bony ring in various directions.

The vertebræ being, as has been said, placed one behind or in front of the other, their juxtaposed rings together form a long horizontal canal (ring being placed opposite ring), which is called the *vertebral canal*. It is also called the *neural* canal, because it is destined to contain and protect the central part of the nervous system of the trunk, namely the spinal cord—or, as it is popularly termed, the spinal marrow.

The thickened inferior parts of the vertebræ are also adjusted one in front of another, and by their juxtaposition form a solid but flexible horizontal rod.

§ 4. The thickened inferior part of each vertebra is called its "body," or *centrum* (see Fig. 16); the ring of the vertebra springing from the centrum is called, as before said, the *neural arch*. Each lateral half of the neural arch consists of two parts: an inferior rounded part called the *pedicle*, and a superior broad and flat portion called the *neural lamina*.

The various bony prominences of the vertebræ are termed "*processes*," and at least three kinds of such processes are very generally present.

The first of these is the process which projects upwards from the junction of the neural laminæ at the summit of the neural arch. This is the *spinous process*, *neural spine*, or *neurapophysis*. From the junction of each lamina with its pedicle another process, ending bluntly, juts outwards and upwards: this is called the *transverse process*. Other processes which project more or less forwards and backwards from the outer part of each lamina to meet corresponding processes of adjacent vertebræ, are termed *articular processes* or *zygapophyses*.

Those projecting forwards have a smooth articular surface, which looks mainly upwards, and are called anterior articular processes, or *prezygapophyses*.

Those projecting backwards have a smooth articular surface, which looks mainly downwards, and are called posterior articular processes, or *postzygapophyses*.

The anterior margin of each pedicle is somewhat concave, while its posterior margin is generally more so. In this way, the vertebræ being naturally juxtaposed, the adjoined concavities, or *notches*, of two adjacent vertebræ, constitute a rounded opening termed an *intervertebral foramen*. These foramina communicate with the neural canal, and enable nerves and vessels to pass thence outwards.

The adjacent surfaces of the bodies of the vertebræ are nearly flat, and are connected together by the intervention of a fibrous pad —the *intervertebral substance*—which will be described later, amongst the ligaments.

The vertebræ are composed of cancellous bony tissue invested by compact bone. The latter is most abundant on the arch and processes. The body of each vertebra is almost entirely composed of spongy substance traversed by canals for veins.

Such is the general condition of most of the vertebræ, but in some of them certain of their parts and processes are wanting, while in others there are additional parts and processes.

§ 5. The vertebræ are divisible into five different CATEGORIES. (See Fig. 23, *c*, *d*, *l*, *s*, and *ca*).

First come those of the neck, which are termed *cervical*. They are seven in number.

Secondly, those of the back, which have the ribs attached to them and are called *dorsal*. Of these there are thirteen.

Thirdly, we find certain large vertebræ which do not bear ribs: these are situate behind the dorsal vertebræ and are called *lumbar*. There are seven of them.

All the above are termed "true vertebræ," because they do not become anchylosed together, but remain connected only by ligaments and by the intervertebral substances.

Behind these true vertebræ come three which are called "false," and which sooner or later anchylose together to form a bony mass.

This mass, termed the *sacrum*, comes immediately behind the lumbar vertebræ, and part of it affords attachment on each side to one of the haunch, or hip, bones. The *sacral* vertebræ thus anchylose together to constitute the sacrum. The rest of the vertebræ are called *caudal*, and form a series of some twenty bones which decrease, gradually, backwards as regards their complexity of structure, but increase in length to about the tenth, and then again become successively shorter, as well as simpler, to the end of the tail.

§ 6. Of the vertebræ, the DORSAL, as the simplest of those in front of the tail, may first be selected for description, the fifth dorsal being taken as the type. The centrum of this vertebra (*c*) is about three quarters as deep from above downwards as it is broad from side to side, its length (from before backwards) being about equal to its breadth. Its upper surface is more or less flattened. Its under surface is strongly convex from side to side,

and somewhat concave from before backwards. Its anterior and posterior surfaces are flattened, but the former is somewhat convex and the latter somewhat concave. The pedicles have their anterior notches very shallow, but their posterior ones very deep. The neural laminæ are almost as wide from before backwards as from side to side, and the neural arch overlaps that of the vertebra

Fig. 16.—Fifth Dorsal Vertebra.

A. The vertebra seen on its right side.
B. Anterior view.
C. Posterior view.
b. Small tubercle.
c. Centrum.
d. Tubercular surface.
p. Capitular surfaces.
s. Neural spine.
t. Transverse process.
Z. Anterior zygapophysis.
3. Posterior zygapophysis.

next behind. The spinous process is very elongated, pointed and inclined upwards and backwards. The zygapophyses are almost horizontal, the anterior ones (*Z*) looking upwards and slightly forwards and outwards; the posterior ones (3) looking downwards and slightly backwards and inwards.

The transverse process (*t*) projects outwards from nearly the summit of each pedicle, almost entirely hiding the anterior zygapophyses when the vertebra is seen in profile. A little tubercle (*b*) projects from the upper surface of the distal part of the transverse process.*

Like almost all the other dorsal vertebræ, the fifth dorsal exhibits certain articular surfaces which are called *costal*, because they serve for the attachments of the ribs. There are two kinds of such surfaces. One kind, attached to the centrum, are called *capitular*, because they articulate with the heads, or the capitula, of the ribs. The other kind, attached to the transverse processes, are called

* "Distal" and "proximal" are two words respectively expressing remoteness from and nearness to a centre or point of attachment. Thus, *e.g.* the paw is the *distal* part of a limb; that part of a limb which joins the body is the *proximal* part. The tip of the tail is "distal;" its root is "proximal."

tubercular, because they articulate with the tubercles of the ribs. The tubercular surface (*d*) is a smooth, oval surface, slightly prolonged from before backwards, and placed one beneath the distal end of each transverse process and giving attachment to the tubercle of the fifth rib.

The capitular surfaces (*p*, *p*) are two in number on each side. One is placed at the junction of the pedicle with the centrum in front; it is smooth, and looks forwards and outwards. The other is placed just beneath the posterior notch of the pedicle; it is smooth, and looks so almost directly backwards and so very little outwards as to form part (the outer and upper angle) of the posterior surface of the centrum. The anterior capitular surface concurs with the posterior capitular surface of the fourth vertebra to form with it an articular cavity for the head of the fifth rib. Similarly its posterior capitular surface concurs with the anterior capitular surface of the sixth vertebra to form an articular cavity for the head of the sixth rib.

The ring formed by the neural arch and centrum is oval, transversely extended, and somewhat flattened below.

The eleventh, twelfth and thirteenth dorsal vertebræ have each but a single capitular surface on each side—namely, an anterior one. The first dorsal has an anterior capitular surface large enough to receive the whole head of the first rib. The eleventh, twelfth and thirteenth vertebræ have no tubercular surface.

The first two dorsal vertebræ have the front surface of the centrum strongly convex and looking much downwards, and its hinder surface concave and looking much upwards. The tubercular surface also is strongly concave.

As we proceed from before backwards, through the series of dorsal vertebræ to the tenth, the transverse processes come to extend less outwards and to be more expanded from before backwards at their distal ends; the postzygapophyses become situated further backwards, and the neural spines (counting, at least, from the seventh,) also become shorter.

The *tenth dorsal vertebra* has its transverse process very much extended from before backwards (Fig. 17,[10]). Its posterior end projects backwards more than in any preceding vertebra, reaching to, or even beyond, the anterior margin of the pedicle of the eleventh vertebra. The postzygapophyses look as much outwards as downwards, or even mainly outwards.

In the *eleventh* dorsal vertebra the neural spine projects more or less forwards (Fig. 17, ^{11} *s*), instead of backwards, abutting against that of the tenth vertebra, which it may, or may not, slightly exceed in length. It has no transverse process, but there are two conspicuous processes on each side, which evidently answer to the processes (one at each end) which terminate the transverse process of the tenth vertebra, but which, in the eleventh vertebra, are quite separated the one from the other.

The anterior process (Fig. 17, ^{11} *a*), which projects forwards,

upwards and outwards, outside the prezygapophysis, is termed the mammillary process, or *Metapophysis*.

The posterior process (*a*), which projects backwards as much as any other part of the vertebra, is called the accessory process, or *Anapophysis*.

The prezygapophyses look almost entirely inwards, while the postzygapophyses (3) look almost entirely outwards.

The twelfth and thirteenth dorsal vertebræ are like the eleventh, but their anapophyses are stouter and their neural spines are larger and project more forward.

§ 7. The seven LUMBAR VERTEBRÆ are larger and more massive than the dorsal vertebræ, and increase in size as we proceed backwards as far as the sixth lumbar (see Fig. 23).

Selecting the fifth for comparison with the fifth dorsal, we find its centrum broader in proportion to its depth, about twice as long, less convex transversely below, and with a slight median ridge, called *hypapophysial*,* running from before backwards, along its under surface. The neural lamina and pedicel are much longer, and the latter, though deeply notched behind, is scarcely at all so in front.

The neural spine is very much shorter, absolutely as well as relatively. It is elongated from before backwards, and inclines forwards instead of backwards, thus agreeing with the last three dorsal vertebræ.

The zygapophyses are thicker, and their articular surfaces are differently shaped from those of the dorsal vertebræ.

Each prezygapophysial surface is concave, and looks inwards as well as upwards. The postzygapophysial surfaces are convex, and look outwards as well as downwards, being embraced by the prezygapophyses of the vertebra next behind. The transverse processes are very much longer than those of the dorsal vertebræ, and project very much forwards and strongly downwards as well as slightly outwards. There are no capitular or tubercular surfaces, the lumbar vertebræ not bearing ribs.

Fig. 17.—SIDE VIEW OF THE TENTH AND ELEVENTH VERTEBRÆ, SLIGHTLY SEPARATED.

10. Tenth vertebra.
11. Eleventh vertebra.
a. Anapophysis.
d. Tubercular process.
m. Metapophysis.
n. Part of transverse process which conceals from view the neural lamina.
p. Capitular process.
z. Neural spine.
Z. Anterior zygapophysis.
3. Posterior zygapophysis.

The metapophyses and anapophyses are large and conspicuous, though not more so than in the last dorsal vertebra.

The neural canal is larger and more quadrangular than in the dorsal region.

The more anterior lumbar vertebræ closely resemble the more

* Because it represents a certain process, present in many other animals, which is called a hypapophysis.

posterior dorsal vertebræ, the first lumbar being quite like the last dorsal, except that it has no capitular surface, but, in its place, a short forwardly extending transverse process, and that the metapophyses are somewhat larger.

As we proceed backwards through the series of lumbar vertebræ,

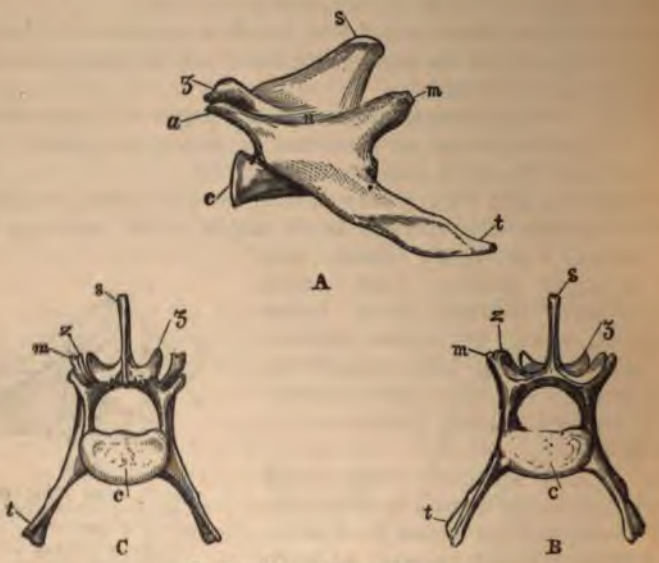


Fig. 18.—Fifth Lumbar Vertebra.

a. Anapophysis.
c. Centrum.
m. Metapophysis.
n. Neural lamina.
s. Neural spine.
t. Transverse process.
z. Prezygapophysis.
3. Postzygapophysis.

the anapophysis decreases, so that in the sixth lumbar there is but a minute rudiment of such a process. The metapophysis is at its maximum in the fourth lumbar vertebra, but is large even in the last. The neural spine is longest at the fourth. The transverse process increases rapidly from the first lumbar vertebra to the fourth, and is slightly longer in the fifth and sixth lumbar vertebræ. The zygapophyses continue to be directed as in the fifth lumbar vertebra, except that the postzygapophyses of the seventh look once again more downwards.

The centrum of the seventh lumbar vertebra is not longer than is that of the first, and the same is the case with the neural arch.

§ 8. Having noted the characters of the vertebræ next behind the dorsal ones, we may advance to those in front of them.

Of the seven CERVICAL VERTEBRÆ the first two are sufficiently exceptional to demand separate notice. The other cervicals are very much alike, but the fifth may be selected for comparison with the fifth dorsal vertebra.

Its centrum is relatively wider from side to side and narrower

from above downwards than in either the dorsal or the lumbar vertebræ. The front surface of the centrum is convex, and looks much downwards as well as forwards, and its hinder surface is concave and looks much upwards as well as backwards. The pedicle is narrow from before backwards, and its anterior notch is as marked as its posterior one; but this appearance is mainly due to the projection forwards of the prezygapophysis (*z*). The neural laminæ are much flattened, and are broadened transversely like the centra. The spinous process is short, small, and projects somewhat forwards. The zygapophyses are large and flat. The articular surface of each prezygapophysis looks upwards, forwards, and

Fig. 19.—Fifth Cervical Vertebra.

A. Side view.
B. Front view.
C. Back view.
c. Centrum.
s. Neural spine.
t. Transverse process.
v. Vertebral canal.
z. Prezygapophysis.
z. Postzygapophysis.

slightly inwards. Its outer surface presents a roughened prominence. The articular surface of each postzygapophysis looks downwards, backwards and slightly outwards.

There is a large plate-like transverse process (*t*) which springs from two roots. One of these descends from the front of the side of the pedicle, the other projects from the centrum, just at the place where the capitular articular surface of a dorsal vertebra is placed, and so may be called a "capitular process." These two short roots unite and enclose a space (*v*) called the *vertebral canal*, because it is traversed by the vertebral artery. Thus this vertebra may be said to have "perforated transverse processes." Beyond the junction of its two roots the transverse process expands into an irregularly quadrilateral plate, one surface of which looks outwards, upwards, and slightly forwards, while the other looks inwards, downwards, and slightly backwards. From near the hinder angle of this plate a process, somewhat like an anapophysis, projects upwards and backwards, so that the plate may be said, at this part, to slightly bifurcate.

The other cervical vertebræ (except the first two) more or less

closely resemble the fifth cervical. The seventh, however, has a longer spinous process (like that of a dorsal vertebra), and no vertebral canal—only that part of the transverse process being developed, which corresponds with root above the vertebral canal and with the anapophysis-like process of the transverse process of the fifth vertebra. These parts, therefore, may be taken to represent the

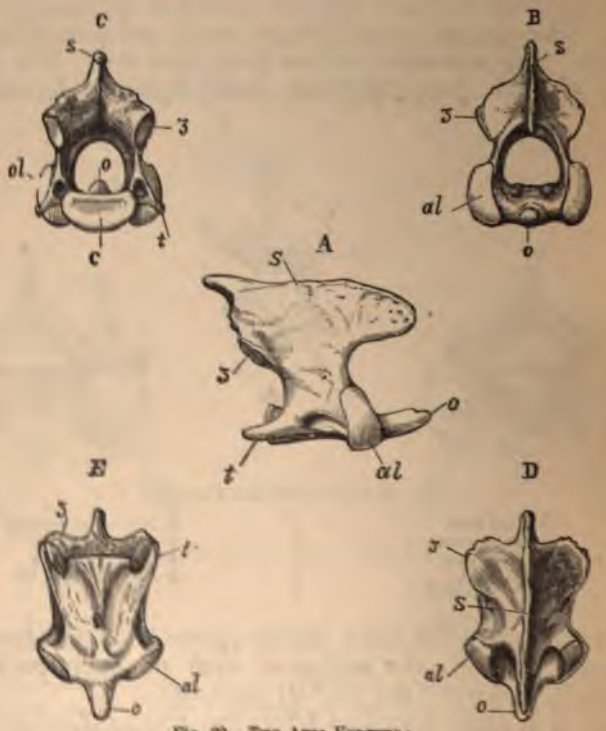


Fig. 20.—The Axis Vertebra.

A. Side view.
B. Front view.
C. Back view.
D. Dorsal view.
E. Ventral view.

al. Anterior articular surface.
c. Posterior articular surface of centrum.
o. Odontoid process.
s. Neural spine.
t. Transverse process.
z. Posterior zygapophysis.

tubercular process of a dorsal vertebra, while the rest of the cervical transverse process, where present, represents a rib.

The sixth cervical vertebra has the anapophysis-like process very large, while the lamellar transverse process is much developed behind and within it, so that the process of bifurcation, which was incipient in the fifth cervical, is, in the sixth, so advanced that the transverse process may certainly be said to bifurcate posteriorly.

In the fourth and third vertebræ the transverse process becomes simpler and relatively more extended from before backwards, but is always perforated.

The convexity outside the prezygapophysis is at its maximum in the fourth vertebra. It is really a rudimentary metapophysis.

The neural laminæ of the sixth and seventh vertebræ show a ridge-like process on the inner side of each postzygapophysis. This is called a *hyperapophysis*.

§ 9. The second cervical vertebra, termed the AXIS, differs conspicuously from every other bone of the spine in having a large blunt

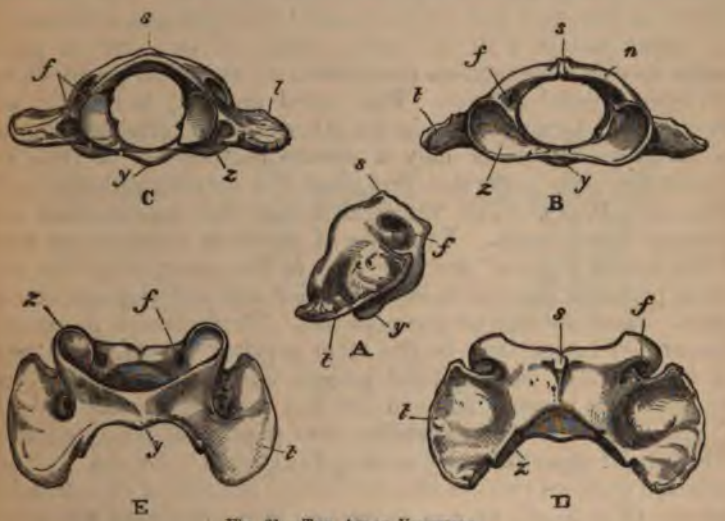


Fig 21.—THE ATLAS VERTEBRA.

A. Side view.
B. Front view.
C. Back view
D. Dorsal view.
E. Ventral view

f. Foramina.
n. Neural lamina.
s. Rudiment of neural spine.
t. Transverse process.
z. Articular surfaces.
y. Hypapophysial tubercle.

process of bone (like a tooth or peg, *o*), extending forwards from the anterior portion of the centrum—on which account the bone is sometimes termed the *vertebra dentata*. This eminence is called the *odontoid* process. It presents a smooth articular surface below, and a smooth groove above. The lower surface of the rest of the centrum of the axis exhibits a median hypapophysial prominence or ridge. The pedicle has a very deep anterior notch, beneath which is an anterior lateral articular surface (*al*), instead of a prezygapophysis. The neural spine (*s*) is merely an elongated ridge extending along the summit of the stout neural laminæ.

The postzygapophyses (*z*) exist as usual, but the prezygapophyses are, as has just been said, absent. There is however instead, on each side, the just mentioned large articular surface (*al*), looking forwards and outwards, and supported on the centrum, beside but behind the odontoid process. The transverse process (*t*) is short, pointed, perforated, and backwardly projecting from near the hinder end of the side of the centrum.

§ 10. The first vertebra of all, called the ATLAS, also differs conspicuously from every other bone of the spine. It differs by the large size of the aperture it encloses and by the smallness of the part which, at first sight, appears to represent the centrum, as also by the absence of a neural spine. The ring it forms is wider above than below, and it is this wider part which corresponds to the neural arches of the other vertebræ. The narrower ventral part receives upon it the odontoid process of the axis. The part which seems to, but does not truly represent the centrum, articulates by its upper surface with the under surface of the odontoid process, while its own under surface developes a slight median prominence (*y*) or *hypapophysial tubercle*. The neural arch (*n*) is slightly wider from behind forwards than in the other cervical vertebræ, and there is no neural spine, or only a minute rudiment of it (*s*). Each neural lamina is perforated just above the anterior articular surface (Fig. 21, B, *f*). The vertebral artery and sub-occipital nerve traverse this foramen. The sides of the atlas vertebra are termed "the lateral masses," and give rise to the great, wing-like, transverse processes (*t*), and to large anterior and posterior articular surfaces. There are no true zygapophyses. The transverse processes are longer and larger than in the other cervical vertebræ, and consist of a tubercular and capitular process, united at their distal ends, or enclosing a small foramen for the vertebral artery (Fig. 21, C and D, *f*), and then expanding into a plate of bone, one side of which looks upwards and the other downwards. Of the four large articular surfaces two are situated behind the root of each transverse process (Fig. 21, C, *z*), and correspond in position with the anterior articular surfaces of the axis, before described. The anterior pair of surfaces (Fig. 21, B and E, *z*) are very large, cup-shaped, and oval, converging inferiorly, and looking inwards as well as forwards. They receive and articulate with two prominences of the hinder end of the skull. At the inner margin of each is a minute, smooth, rounded tubercle. The hinder pair of articular surfaces (Fig. 21, C and D, *z*) are smaller than the anterior pair, and are more elongated in shape and flatter. They are inclined a little inwards as well as upwards and backwards, and join the anterior articular surfaces of the axis vertebra.

The atlas is formed to turn on the odontoid process of the axis as on a pivot, as will be further explained when the ligaments come to be described.

§ 11. Next to be noticed are the three (sometimes four) vertebræ which are often called "false," because they anchylose together into one bony mass, and so constitute the SACRUM.

This bone immediately succeeds the hindmost lumbar vertebra, and is roughly quadrangular in form, but the transverse diameter of its hinder end is considerably less than that of its anterior portion.

The composite nature of the sacrum is plainly manifested (in the fully ossified bone of even the most aged individuals) by its processes and perforations, and by the transverse markings of its ventral surface.

s first component vertebra is considerably larger than the two succeeding ones, which are about equal in size.

The ventral surface of the sacrum (A) is markedly concave from efore backwards, and is also concave transversely at its more anrior part. It is marked by two transverse lines (which indicate ie original limits of the vertebral centra), and at each end of each ne is a considerable aperture or foramen (*f*). These four openigs, called the *ventral sacral foramina*, give exit to the anterior ivisions of the sacral nerves.

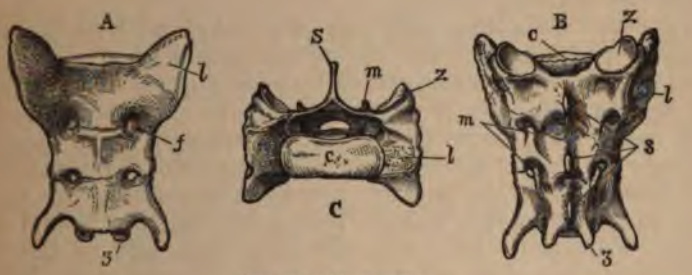


Fig 22.—The Sacrum

A. Ventral view.
B. Dorsal view.
C. Front view.
c. Anterior central articular surface.
f. Foramina.
l. Lateral masses.
m. Rudiments of zygapophyses and metapophyses conjoined.
s. Neural spines.
z. and 3. Zygapophyses.

The dorsal surface of the sacrum is rough, and exhibits three neural spines (*s*) projecting nearly straight upwards. They are all shorter than the neural spine of the last lumbar vertebra, and the third sacral neural spine is much smaller than the two in front of it, whereof the first is the taller.

External to the neural spines, and at the outer margins of the neural laminæ (which form a completely roofed neural canal throughout the sacrum), there are, on each side, four eminences, representing zygapophyses or metapophyses, or both (*m*). Thus at the anterior end of the centrum we have (*z*) on each side a prezygapophysis (with its outer margin prolonged by the metapophysis), which is like that of the last sacral vertebra, except that it is somewhat larger. Behind this there is a smaller prominence, which represents the conjoined metapophysis and zygapophysis anchylosed together at the junction of the first and second sacral vertebræ. Behind this, again, there is another still smaller prominence which represents the same parts at the junction of the second and third sacral vertebræ. Behind this again, and close behind the third sacral neural spine, is a third process (which is the postzygapophysis of the third sacral vertebra) which articulates with the first vertebra of the tail (3).

Just external to each process formed of coalesced and anchylosed zygapophyses, is a considerable aperture or foramen. There are four such, and these are termed the *dorsal sacral foramina*, and they

are placed directly over the ventral sacral foramina before described. The bony substance of each sacral vertebra projects outwards beyond these foramina, forming what is called the "*lateral masses*" of the sacrum (*l*), which are in fact the coalesced transverse processes of the sacral vertebræ.

The formation of the ventral and dorsal sacral foramina may be thus explained. Nerves in the true vertebræ pass out, as we have seen, between the pedicles of adjacent vertebræ. Now the coalescence of the sacral transverse processes necessarily changes each such intervertebral opening into a pair of openings, of which one is dorsal and the other ventral.

In a line connecting each pair of dorsal sacral foramina, slight irregular perforations in the roof of the neural canal indicate the primitive interspaces which existed between adjacent sacral vertebræ. At the anterior end of the sacrum is an articular surface (*c*), very wide but narrow from above downwards, which joins the centrum of the last lumbar vertebra. Above this is the opening of the neural canal, also greatly extended transversely, and narrow from above downwards, and the prezygapophyses and neural spine before mentioned. Extending out from each side of the front articular surface of the centrum are the two "lateral masses," which project strongly outwards, downwards, and somewhat forwards.

At the posterior end of the sacrum there is a small oval articular surface, which joins the centrum of the first caudal vertebra. On each side of it the "lateral masses"—here small, thin bony plates—project outwards. Above it is the small crescentic opening of the hinder end of the sacral neural canal, surmounted by the neural spine and postzygapophyses (*z*) before mentioned.

The sacrum, viewed laterally, exhibits the neural spines, zygapophyses, and dorsal foramina before described, and below these one of the lateral masses, which appears deep in front and tapers rapidly backwards. On its deep part is a large irregular surface which in the living animal is coated with cartilage, and articulates with the hip or haunch-bone. This surface is somewhat crescentic with the concavity upwards, and is called the *auricular surface*, because the corresponding part in man has an outline somewhat resembling an ear. Above this surface the lateral mass is more or less excavated and uneven. The auricular surface may be entirely supported by that part of the lateral mass which pertains to the first sacral vertebra; it may, however, extend on to part of that pertaining to the second sacral vertebra. That part which pertains to the third sacral vertebra ends behind in a pointed process extending outwards as well as backwards to about the level of the middle of the sacrum's hinder central surface.

§ 12. The last part of the cat's spine is formed by the CAUDAL VERTEBRÆ (see Fig. 23), usually about eighteen or nineteen in number, but sometimes as many as twenty-four. Of course the short-tailed breeds have only a few caudal vertebræ. In the Manx cat there are four, and in the Malay cat several of the vertebræ

towards the middle or more distal part of the tail are distorted, atrophied, and more or less fused together at the place where the tail is so suddenly contorted.

With age, the first caudal may anchylose with the third sacral vertebra, which it resembles much both in size and shape, though its neural spine is smaller and its transverse process (which projects strongly backwards and slightly outwards) is narrower from behind forwards than is the lateral mass of the third sacral vertebra. The two next caudal vertebræ closely resemble the first, though they are slightly longer. The *fourth caudal* vertebra is again longer, its neural spine is hardly to be detected, and its shorter transverse processes project outwards and backwards from the hinder part of the side of its centrum. Two slight hypapophysial prominences are also to be detected side by side and but little separated, at the anterior end of the ventral surface of the centrum. The neural canal is also much reduced in size. The *fifth caudal* vertebra exaggerates the same characters, as also does the sixth, in which the neural canal is very small. Here also a minute transverse process begins to show itself projecting outwards from the anterior end of each side of the centrum, while that projecting from its posterior end is so reduced as to be scarcely, if at all, larger than is the transverse process thus newly appearing at the anterior end of this vertebra; in which, moreover, the prezygapophyses no longer articulate with the postzygapophyses in front of them.

In the seventh caudal vertebra the minute neural canal is hardly enclosed by bone, and is only so near the median part of the bone. The prezygapophyses are the longest processes, and the anterior transverse processes are rather longer than the posterior ones. The transverse processes in the *eighth vertebra* are hardly more prominent than are the hypapophysial ones, but the whole bone continues to increase in length. In the *ninth vertebra* there is an open groove instead of a neural canal. The *tenth* is about the absolutely longest vertebra. Thence onwards the processes become less and less marked, and the vertebræ, from the eleventh or twelfth, begin manifestly to decrease in length and all other dimensions—the last vertebræ being little more than small cylindrical ossicles, each formed of a centrum only, with faint indications at each end of processes corresponding with those described as existing in the more anterior vertebræ. Thus the last vertebra is the very opposite to the first (or atlas), being all centrum, while the atlas has no proper centrum at all.

Certain very small Y-shaped bones called *chevron bones* are articulated beneath the interspaces and adjacent ends of the caudal vertebræ, from the second to the tenth or eleventh vertebra.

§ 13. The WHOLE SERIES of vertebræ thus form a jointed rod—the spinal or vertebral column. Its component vertebræ, moreover, are so disposed that the backbone, when seen in profile, presents, between the atlas and the tail, two curvatures (see *ante*, Fig. 2), directed alternately upwards and downwards. Thus the cervical vertebræ form a curve which is convex downwards, while

Fig. 23. — VENTRAL ASPECT OF THE VERTEBRAL COLUMN.
c. Cervical,
d. Dorsal,
l. Lumbar,
s. Sacral, and
ca. Caudal vertebræ.

the dorsal and lumbar vertebræ togethe
a curve which is much more strongly
upwards than the preceding curve is
downwards. The neural spines (which are
in the dorsal vertebræ) change their dire
about the middle of the posterior curve,
the tenth dorsal vertebra inclining bac
and that of the eleventh forwards, their j
indicating the centre of motion.

The breadth of the ventral part of th
bone (*i.e.* the transverse diameter of the v
centra), narrows slightly from the axis to t
dorsal vertebra; it remains much the s
about the fifth, and then gradually widen
first sacral, whence it again decreases
to the beginning of the tail, and th
gradually to the end of that organ. Th
of the column, including the transver
cesses and the lateral masses of the sa
at its maximum at once at the atlas, a
denly decreasing at the axis. It thence
much the same, but gradually broadens
first dorsal, whence it again very g
narrows to the last dorsal vertebra. The
once increases rapidly to the last lumbar
which is about as wide as is the atlas.
backwards the spine gradually narrows to
of the vertebral series.

The ventral surface of the vertebral
bears no median prominence save th
longitudinal one beneath the centrum of
and of certain lumbar vertebræ, together
tubercles of the atlas and of some caudal
and the chevron bones. The dorsal surfac
median series of spines, which are longe
anterior dorsal and lumbar vertebræ.
variously directed, as has been already de

On each side of the series of spinous
are the neural laminæ forming the botto
"*vertebral grooves*," each of which is bou
ternally by the transverse, zygapophy
metapophysial processes, and internally
spinous processes. Each groove is br
shallow in the neck, and deeper and
in the anterior thoracic region, and d
all at the lumbar region. The laminæ o
the neck and in the anterior and midd
the dorsal region. They leave an op
between them in the lumbar portion of
tebral column.

14. Having considered the dorsal part of the axial skeleton—backbone—we may now proceed to consider that opposite, or *ral* structure, the BREASTBONE, together with those parts (the *ribs*, their cartilages), which connect the backbone and breastbone ther. The breastbone and ribs, with the dorsal vertebræ, to

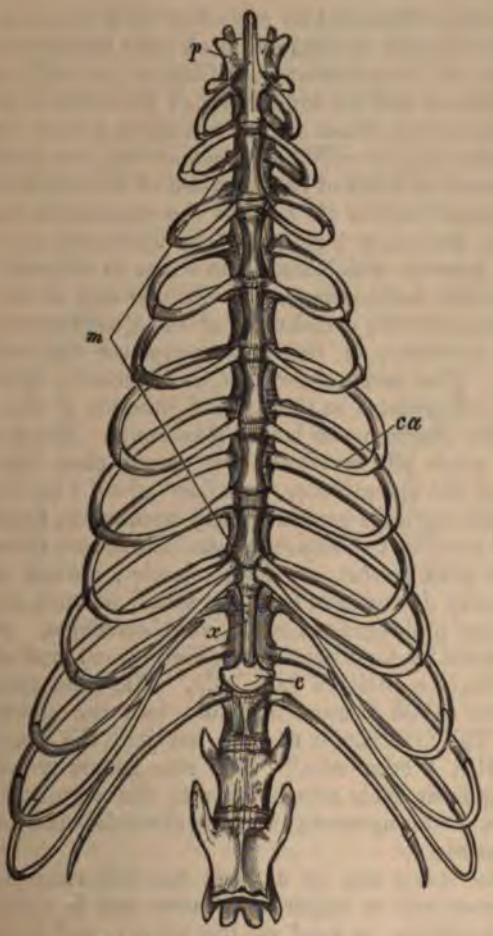


Fig. 24.—SKELETON OF THE THORAX.

End of xiphoid cartilage.
One of the costal cartilages.
Sternebræ of body of sternum
x. Xiphoid process.
p. Presternum or manubrium.

h the ribs are dorsally attached, together constitute the skeleton e *thorax*. The thoracic part of the axial skeleton thus forms a of bony cage in which, during life, those most important organs, heart and lungs, are sheltered and protected.

15. The breastbone, or STERNUM, extends along the ventre

portion of the trunk in the middle line, but it is very much smaller and less complex than is the backbone. It is flattened from above downwards, but still more so from side to side, and consists of a chain of eight bones, called *sternebræ*, about fifteen or sixteen times as long as broad, but its width varies slightly at intervals throughout its whole extent.

The sternum is connected on each side with the cartilages (*ca*) of the first nine ribs, one cartilage on each side being attached to each successive pair of sternebræ at their junction, as well as to the sides of the manubrium and the hinder end of the seventh sternebra.

The first sternebra, which ends anteriorly in a laterally compressed pointed process (*p*), is called the *manubrium*, or *presternum*, and extends forwards in front of the insertion of the cartilage of the first rib. The second part (or *the body* of the sternum) is made up of the other six sternebræ together. The third part (*x*) is the *xiphoid* or *ensiform*, process, which varies in shape in different individuals and long remains cartilaginous. The hinder end of the manubrium affords a surface for the attachment of the second costal cartilage.

The first sternebra of the *body* completes the surface for the second rib. The notches for the third, fourth, fifth, sixth and seventh ribs are situated at the lines of junction of the sternebræ of the body of the sternum—as before mentioned. The notches for the eighth and ninth rib cartilages are placed close together at the hinder end of the seventh sternebra (see below, Fig. 78, B, *f*).

This *xiphoid* cartilage projects freely backwards, tapering towards its generally more or less expanded and fan-shaped distal end (*c*).

§ **16.** The RIBS (*costæ*) are long, slender, curved bones, which extend obliquely downwards from the spinal column, and end below in cartilaginous prolongations called *costal cartilages*. Some of these join the sternum by their cartilages (Fig. 24, *ca*), and others do not. There are thirteen ribs on each side. The nine anterior ribs on each side are called "true ribs," and join the sternum by their cartilages. The four hinder ribs do not join the sternum, and are therefore called "false ribs." The ribs generally are curved at first (starting from their attachments to the vertebral centra) outwards and a little upwards, then backwards, and outwards and much downwards.

Taking the SIXTH RIB as a type, the following points may be noted: its proximal or upper and inner end is thickened, and is called the *capitulum*, or *head*, of the rib (*c*), and it is this which joins the capitular surfaces of the fifth and sixth dorsal vertebræ by two corresponding oblique articular surfaces, with a ridge between. The part of the rib next to the head is termed the *neck* (*n*), and this short portion terminates at what is called the *tuberculum* (*t*), or tubercle of the rib. This is a rounded prominence on the hinder border of the bone. It looks upwards, and presents a smooth surface for articulation with the transverse process of the sixth dorsal vertebra; outside this smooth prominence is a rough surface of bone. The neck of the rib is narrower than is the first part

of the "body,"—the "body" of the rib being all that portion which is distal to, or beyond, the tubercle. This body (*b*) is somewhat flattened from before backwards at its upper part, and slightly expanded in the same direction at its distal end, the intervening part being nearly cylindrical. It exhibits a faint indication of a groove running along its hinder side, especially at the upper part of its body. A little beyond the tubercle the bone makes a sudden bend downwards (*a*). This part is termed the *angle*, and it is behind it that the groove just mentioned is most distinctly developed, while in front it exhibits a roughened line for muscular attachment.

The distal end of the bone is hollowed out into an oval pit (*p*), and into this the sixth costal cartilage is inserted.

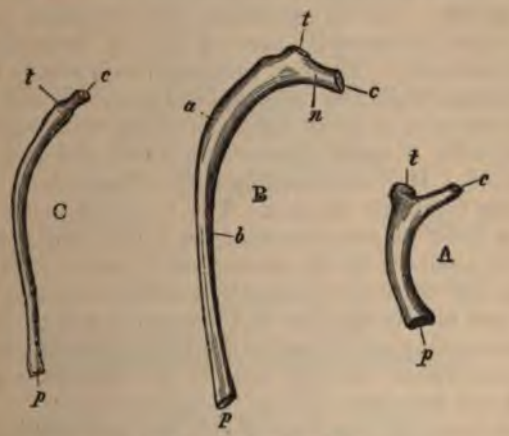


Fig. 25.—SIDE VIEW OF RIBS.

A. First rib.
B. Sixth rib.
C. Thirteenth rib.
a. Angle.
b. Body.
c. Capitulum.
n. Neck.
p. Pit for costal cartilage.
t. Tuberculum.

The other true ribs differ but slightly from the sixth, except as to length, which decreases as we pass forwards or backwards from the ninth, which is the longest rib.

The first rib is the broadest of all (Fig. 25, A), especially towards its proximal end. Its capitulum has but one articular surface. The "angle" about coincides in position with the tuberculum.

The false ribs decrease in length backwards, but the last rib is longer than even the fourth true rib.

The three foremost false ribs (the tenth, eleventh and twelfth) are united together by their costal cartilages, but the thirteenth rib ends freely, and is thence termed a *floating rib*. The last rib (Fig. 25, C), has but a minute rudiment of a tuberculum or none, and the capitula of the last three ribs have each but one articular surface.

The *angles* of the ribs become more and more distant from the tubercula as we pass backwards to the eleventh rib. The thirteenth exhibits no angle.

§ **17**. The COSTAL CARTILAGES (Fig. 24, *ca*), differ much as to length, connexion, shape and direction. The tenth is the longest, and thence the length decreases as we pass either forwards or backwards through the series. The first nine join the sternum. That of the tenth rib joins the costal cartilage of the ninth rib, and similarly the eleventh and twelfth costal cartilages unite distally with the lower border of the costal cartilage next in front. The thirteenth costal cartilage ends freely. The first costal cartilage is the broadest, and thence they gradually narrow backwards. The last cartilage is pointed at its distal end. The upper (proximal) end of each costal cartilage is convex, and fits into the distal concavity of its rib. As to direction, the cartilages pass at first backwards, then downwards, curving distally forwards from the fourth to the seventh. The first cartilage has a nearly horizontally forward direction, while the last extends downwards and backwards.

§ **18**. The THORAX AS A WHOLE forms a long, transversely narrow, conical case, with a small aperture in front and a wide oblique opening behind. It is considerably deeper from above downwards than it is wide from side to side. The variation in its dimension, which shows itself as we proceed, from before backwards through the thorax, is produced by the corresponding variation in the length of the ribs and in their curvature. The anterior opening is bounded by the first pair of ribs, the first dorsal vertebra and the manubrium. The posterior opening is bounded by the xiphoid process, the cartilages of the four hindmost ribs, the body of the thirteenth rib and the thirteenth dorsal vertebra.

§ **19**. Such being the structure of the bony and cartilaginous parts which make up the spinal portion of the axial skeleton, we have next to consider the fibrous bands, or LIGAMENTS, which hold together the bones and cartilages already described. The substance interposed between each pair of true vertebræ is an elastic body termed an *intervertebral disc*.

Each such disc is made up of concentric lamellæ (Fig. 26, *f*), of fibro-cartilaginous and fibrous tissue, surrounding a soft central portion (*g*), which is very elastic (projecting beyond the general level of the disc when pressure is removed) and contains numerous nucleated corpuscles like those of cartilage.

The surface of each centrum is covered (except towards its circumference) with a thin layer of cartilage, and it is to it that the intervertebral discs are attached.

These discs form so many elastic pads, and one such is placed between each pair of presacral vertebræ, except between the atlas and the axis.

A strong band of fibres, called the *ventral common ligament*, extends along the ventral surface of the vertebral bodies. It is thickest where it passes over the middle of the centra than elsewhere, and

thus tends, by filling up depressions, to render the surface of the vertebral column more even.

Another band of fibres, called the *dorsal common ligament*, passes backwards within the neural canal along its ventral surface from the skull backwards.

Each pair of articulating zygapophyses is surrounded and enclosed by a fibrous bag, the fibres passing from one zygapophysis to the other. Such a surrounding and enclosing membrane is termed a *capsular ligament*. Enclosed within the capsular ligament is a

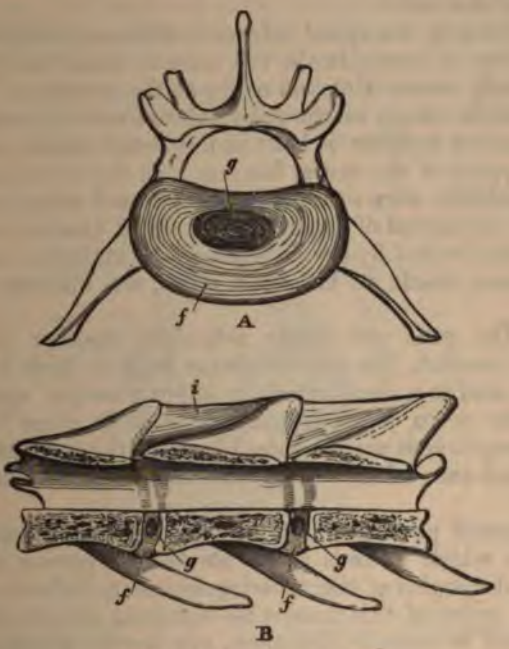


Fig. 26.—INTERVERTEBRAL DISCS.

A. Surface view enlarged.
B. Section through two discs.
f. Lamellæ.
g. Soft central portion.
i. Interspinous ligaments.

membrane which secretes an albuminous fluid termed *synovia*. Membranes of the kind are therefore termed synovial, and are placed between hard parts which are destined to move one on the other. Synovial membranes will be more fully noticed in the description of the different kinds of joints at the end of the next chapter.

Certain ligaments with much yellow elastic tissue, called the *ligamenta subflava*, pass between the neural lamina, being attached to the inner or ventral surface on one neural lamina and thence passing backwards to the anterior margin of the neural lamina next behind. They are thus best seen when the neural arches are removed and viewed on their ventral aspect.

Adjacent spinous processes are also connected together by membranes (Fig. 26, B, *i*), called *interspinous ligaments*. Narrow bundles of fibres, forming a sort of cord, pass backwards along the spinous processes. These are the *supraspinous ligaments*.

A forward prolongation of these supraspinous ligaments is termed the *ligamentum nuchæ*, and passes from the cervical neural spines to the skull.

Adjacent transverse processes are also connected together by fibrous bands termed the *inter-transverse ligaments*. These are largest in the lumbar region, while they are rudimentary in the vertebræ of the neck.

The *mobility* of the spinal column is different in different regions, being greatest of course in the tail (save in some breeds), which can be bent freely in any direction owing to the absence of interlocking bony processes, except in the most anterior caudal vertebræ. After the sacrum, the mobility is least in the dorsal region, on account of the overlapping of the neural laminæ. In the cervical region there is much mobility, even apart from the axis and atlas, the motions of which will be treated of separately. Lateral bending and rotation are variously limited by the direction of the articular surfaces of the zygapophyses, which, as has been noted, are different in different regions.

§ **20.** The AXIS and ATLAS articulate together in a manner altogether peculiar. The atlas (with the head to which it is attached) can turn round to a great extent in either direction upon the odontoid process as on a pivot, being retained in place by ligaments. Synovial membranes are interposed between the articular surfaces of the atlas and axis, which surfaces are kept in apposition by capsular ligaments.

The odontoid process is kept in place by the *transverse ligament of the atlas*, which extends across above that process and between the internal margins of the anterior articular surfaces of the atlas. From the midst of this transverse ligament two bundles of fibres are given off in opposite directions, one bundle passing backwards to the centrum of the axis, the other forwards to the skull, thus giving rise to the figure of a cross.

A synovial membrane is placed both above and below the odontoid process, corresponding with the two smooth surfaces which have already been noted as existing upon it.

Three ligaments pass forwards from the odontoid process to the skull, *i.e.*, one from its tip to the margin of the opening of the skull in front, and two others (called *alar* or *check ligaments*) from the sides of the summit of the process to the inside of the condyles of the skull.

These crucial and odontoid ligaments are covered over above and sheltered by another called the *occipito-axial ligament*, which is placed in the ventral part of the neural canal between them and the most anterior part of the dorsal common ligament. It passes up from the centrum of the axis to the inside of the floor of the skull.

Another ligament, the *ventral occipito-atlantal ligament*, passes from the front ventral border of the atlas forwards to the adjacent part of the skull, and similarly the *ventral atlanto-axial ligament* connects the ventral arch of the atlas with the centrum of the axis. Certain other ligaments connect together the neural arch of the atlas with that of the axis and with the skull. The first of these is the *dorsal atlanto-axial ligament*, connecting the neural arches of the axis and atlas. Another is the *dorsal occipito-atlantal ligament* (Fig. 27, [1]), which connects the neural arch of the atlas with the adjacent margin of the posterior aperture of the cranium. A third ligament, the *transverse atlanto-occipital* ([5]), passes outwards upwards and forwards on each side from the neural arch of the atlas to the inner side of the adjacent occipital condyle. Yet another ligament may be called interspinous. It connects the neural spine of the axis with the middle of the dorsum of the neural arch of the atlas.

§ 21. As to the ribs, a ligament, named "*stellate*," passes, in a

Fig. 27.—Ligaments of Atlas and Axis.

1. Dorsal occipito-atlantal ligament.
2. Dorsal atlanto-axial ligament.
3. Interspinous ligament.
4. Rectus lateralis muscle.
5. Transverse atlanto-occipital ligament.
so. Supra-occipital.

radiating manner, from the ventral surface of the head of each rib on to the intervertebral substance opposite to it, and on to the bodies of the two adjacent vertebræ.

Another ligament, named *inter-articular*, passes transversely from that ridge on the head of the rib which divides its two articular surfaces, to the intervertebral substance. This ligament of course does not exist in the articulations of the first, eleventh, twelfth, and thirteenth ribs, which have each but one articular surface.

The ribs, except the first and the last three, are also connected with the transverse processes, each by certain other ligaments; but none of these attachments prevent each rib from performing a slight movement backwards and forwards upon its vertebral attachment, as well as a certain movement of rotation.

The pieces of the sternum are connected by cartilage, and bound

together both in front and behind by ligamentous fibres, and such fibres surround the articulations of the costal cartilages with the sternum, and thence radiate over the latter both dorsally and ventrally. The various articulations of the ribs with the vertebræ and of the costal cartilages with the sternum, are furnished with synovial membranes. Thus a movement of the ribs backwards and forwards alternately is facilitated, and such movements, we shall hereafter see, are continually repeated in the process of breathing.

THE SKELETON OF THE HEAD.

§ 22. The remaining part of the axial skeleton is that familiarly

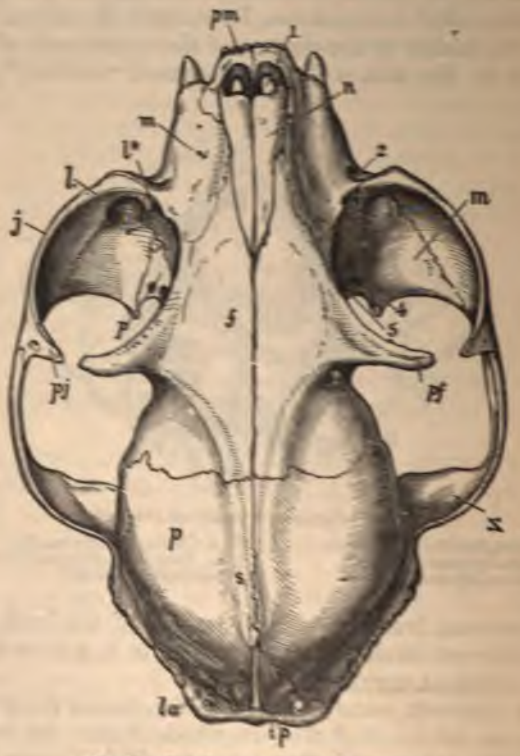


Fig. 28.—The Skull, viewed Dorsally.

f. Frontal.
j. Malar.
l. Lachrymal
l.* Lachrymal foramen.
la. Lambdoidal ridge.
m. Maxillary.
n. Nasal.
p. Palatine.
pf. Post-orbital process of frontal.
pj. Post-orbital process of malar.
pm. Premaxilla.
s. Sagittal suture.
s. Posterior pier of zygomatic arch.
1. Incisive foramen.
2. Infra-orbital foramen.
4. Posterior palatine foramen.
5. Spheno-palatine foramen.

known as the SKULL. This bony structure affords shelter to the brain, and is also the seat of certain organs of special sensation—

nely, those of hearing, sight, and smell. It may be described an irregularly and complexly shaped osseous box with an arch, e a flying buttress, on each side, all forming one coherent mass, l with very diversely conditioned arches appended below and not ilarly coherent. The first of these inferior arches is the skeleton the lower jaw, or *mandible*. The second is the bony framework which the tongue is attached, the *hyoid*. Both these inferior hes readily fall away from the rest of the skull when the soft ts are dissolved or otherwise removed.

Apart from these arches (both inferior and lateral) the skull sists of a spheroidal posterior portion (*p*), to which is annexed front an elongated, narrower, and irregularly quadrilateral part, de up of the bones of the face. On each side of the skull (just front of the spheroidal portion) is a large smooth concave surface ith the concavity outwards), which forms the inner wall of the mber for the eye, or the *orbit*; and the skull is especially narrow m side to side at the hinder and lower part of this region.

The greater part of the upper region of the skull is smooth and n, and crossed by undulating lines of bony union called *sutures*(*s*). When a section is made lengthways (Fig. 49) through the skull, spheroidal portion is shown to bound a great posterior cavity (for brain), in front of which is a more solid region—the quadrangu- part—which includes the bones of the nose (Figs. 49 and 50, *et*), and is placed above the mouth and between the eyes.

he skull consists of two parts:—

(1). The brain-case, skull proper, or *cranium*.

(2). The skeleton of the face.

ertain conspicuous openings and prominences are found in different ons.

he projecting portion of the back of the head is termed the *put*, and at its inferior hinder part is a large hole, looking down- rds and backwards, termed the *occipital foramen*, or foramen gnum (Figs. 29 and 47, *fm*). On each side of this hole, forming rt of its margin, is a rounded projection; and these projections gs. 29 and 47, *oc*), termed "occipital *condyles*," articulate with cup-shaped articular concavities on the anterior side of the atlas rtebra (Fig. 21, B, *z*). Thus, all but the front part of this foramen which the odontoid process is attached by ligament) coincides with corresponding portion of the ring of the atlas vertebra, and the erior of the skull forms the expanded anterior end of the vertebral ral canal.

If the skull be turned base upwards (Fig. 29) a large globular minence (*b*) will be seen a little in front of and external to each ipital condyle. Each such prominence is called, from its connec- with the internal ear, an *auditory bulla*. Between the bullæ, under surface of the cranium extends forward as a narrow flat face (Fig. 29, *bo* and *ps*), bounded laterally by two low, elongated y plates (*pt*), external to which is, on either side, the wide cavity he orbit enclosed by the bony arch just referred to, which arch is

termed the *zygoma* (*Z*). At the hinder end of the zygoma is a transversely extended, smooth concavity called the *glenoid* surface (*g*).

The under surface of the face (formed by the bones of the roof of

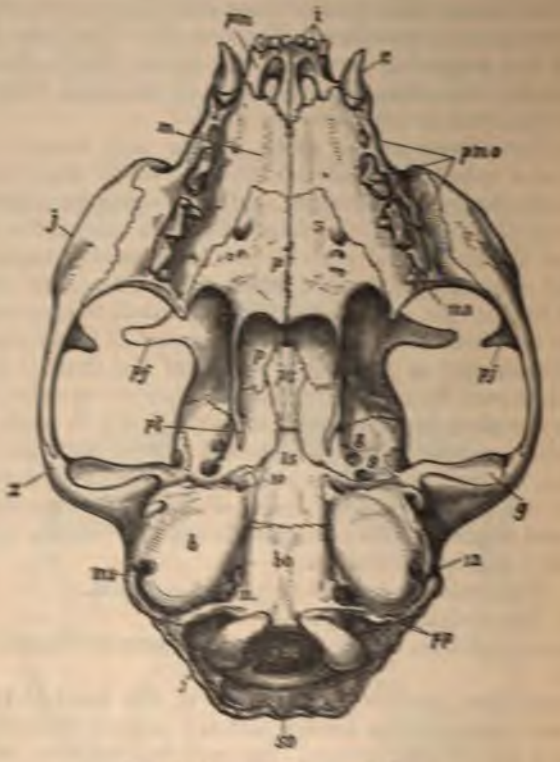


Fig. 28.—Under Surface of Skull.

The two openings enclosed by the pre-maxillæ and maxillæ are the anterior palatine foramina.

b. Auditory bulla.
ba. Basi-occipital.
bs. Basi-sphenoid.
c. Canine.
fm. Foramen magnum.
g. Glenoid surface.
i. Incisors.
j. Malar.
m. Maxilla.
mx. Molar.
ms. Mastoid process.
oc. Occipital condyle.
pp. Palatine (placed one above, the other beneath the opening of the posterior nares).
pf. Post-orbital process of frontal.
pj. Post-orbital process of malar.
pmx. Pre-maxilla.
pmx. Pre-molars.
pp. Pre-occipital process.
ps. Pre-sphenoid.
pt. Pterygoid process.
so. Supra-occipital.
Z. Posterior root of zygoma.
1. Palatine foramen.
8. Sphenoidal fissure and foramen rotundum.
9. Foramen ovale.
10. Eustachian opening.
11. Foramen lacerum posterius.

the mouth) lies at a slightly different level from that of the base of the cranium. The two low, elongated bony plates (*pf*) just spoken of connect these two surfaces together on each side, but in the middle line, leave a vacuity between them, which is the hinder opening of the nostrils, or *posterior nares* (shown, in Fig. 29, by the

low in front of *ps*), which bounds the base of the cranium in from he foramen magnum bounds it behind.

he middle of the hinder part of the under surface of the face s forms the ventral margin of the hinder nostril, while on either , the face receives the termination of the arch of the zygoma. thence narrows as it proceeds forwards, forming a triangular y plate, slightly truncated in front, and bordered by teeth.

When the skull is looked at in front, we see on each side of its hest part, with its rounded outline (the forehead), the great

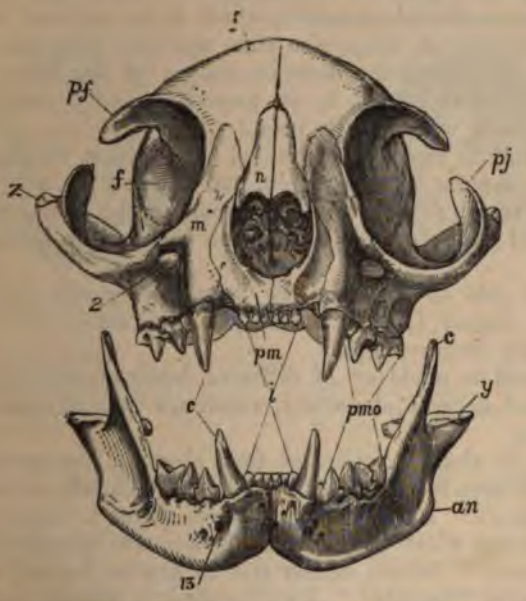


Fig. 30.—Skull viewed from in front, with the Lower Jaw detached.

a. Angle of mandible.
c. Canines.
c. (Of lower jaw) coronoid process.
f. Frontal.
i. Incisors.
m. Maxilla.
n. Nasal.
pf. Post-orbital process of fronta..
pj. Post-orbital process of malar.
pm. Pre-maxilla.
pmo. Pre-molars and inferior true molar.
y. Condyle of mandible.
2. Infra-orbital foramen.
13. Mental foramen.

kets for the eyes, termed the *orbits*. These are not completely rounded by bone, but are bounded below and externally by the oma and a process (*pj*), and above by another process (*pf*) from the ll roof, and behind by the wall of the cranium. The part of the ll which juts out laterally to support the floor of the orbit is called "malar prominence." Between the orbits is the bony pro- ence of the nose, beneath which is a small, somewhat heart- ed aperture, the front bony nostrils or *anterior nares*.

eneath each orbit is the small bony cheek, and the skull is ded below (the lower jaw or mandible being removed) by the lar border giving attachment to the teeth.

When the skull is viewed in profile its upper margin is seen to present an even, rounded contour. Its lower margin is nearly straight, with irregular prominences. The line of the occiput (Fig. 46, *c* to *y*) inclines somewhat backwards as it ascends. In front, the skull is bounded by the margin of the anterior nares.

The zygoma arches upwards, backwards, and then downwards to the front of the auditory bulla, enclosing, as well as the orbit, a fossa named "temporal," because a muscle called the "temporal muscle" is there placed. Behind and beneath the hinder end of the zygoma is a noticeable aperture, which is the external bony opening of the ear (*ae*). A ridge also runs upwards from the malar prominence, and forms the anterior margin of the bony orbit. The orbit is bounded behind by an ascending and a descending post-orbital process, which nearly meet.

The skull is said to be divided into certain *regions*. Thus we have the base or *basilar* region, and opposite to it the vertex, or *sincipital* region; we have the region of the forehead, or *frontal* region, and opposite to it that of the back of the head, or *occipital* region.

At the side of the head we have, posteriorly and above, the *parietal** region (*p*); beneath this, and within the arch of the zygoma, the *temporal* region.

The skull is made up of different bones of very different sizes, shapes, and degrees of density, which are variously united together by sutures.

When the skull is looked at from above, a transverse zigzag line of union is seen to run across behind the forehead; this is called the *coronal* suture. Its zigzag appearance is due to the interlocking of little processes which project from the adjacent margins of the bones, the presence of which causes the suture (or line of union) to be what is called "dentated." Running directly backwards and forwards from this, along the middle line of the skull, is another suture—at right angles to the former—termed *sagittal* (Fig. 28, *s*). The sagittal suture ends posteriorly by joining a wide V-shaped suture with the apex upwards, which is called *lambdoidal*.

Turning now to the lower jaw; this when attached to the skull is seen to fit, by a cylindrical-shaped head, or "*condyle*," into a depression placed on each side in front of the external auditory opening, the *glenoid* surface before mentioned.

The number of bones forming the skull decreases with age, by anchylosis. In its mature condition the skull of the cat consists of the following twenty-seven bones: the occipital, two parietals, two frontals, two temporals, the sphenoid, the presphenoid, the ethmoid—which ten bones compose the cranium, or skull proper; two maxillaries, two premaxillaries, two nasals, two malars, two lachrymals, two palatines, two turbinals, one vomer, one mandible (in two

* Because it is here the "parietal bone" is situate.

parts), and the hyoid bone*—seventeen bones in all, form the skeleton of the face.

§ 23. The OCCIPITAL BONE is of course that of the occiput, and it surrounds the great occipital foramen, or *foramen magnum* (*fm*). When detached, it is seen to be somewhat lozenge-shaped, but rounded above and truncated below. It is made up of a crescentic plate of bone extending above and beside the foramen magnum, and of another narrower and quadrangular plate of bone, which, joining

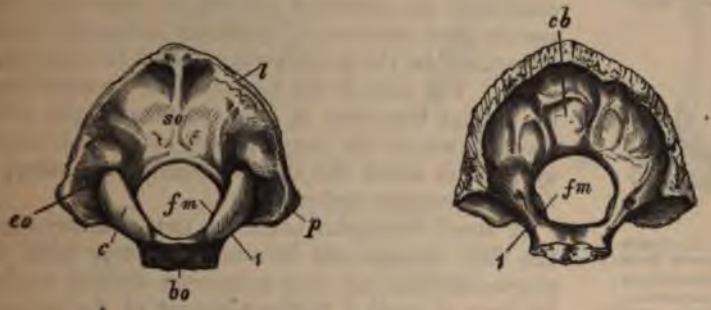


Fig. 31.—THE OCCIPITAL.

A. External surface.
B. Internal surface.
bo. Basi-occipital.
c. Condyle.
cb. Cerebellar fossa.
eo. Ex-occipital.
fm. Foramen magnum.
l. Lambdoidal ridge.
p. Par-occipital process.
so. Supra-occipital.

the other, bounds the foramen magnum below, and thence extends forwards.

The part above the great foramen (*so*) is the *supra-occipital* bone, while the parts placed one on each side of it (*eo*) are the *ex-occipitals*, the quadrangular plate in front (*bo*) is the *basi-occipital*, and these four are all separate and distinct bones in the young kitten.

The margin of the supra-occipital projects outwards as a bony ridge (*l*), which descends on each side of the occiput, and is called the *lambdoidal ridge* or *occipital ridge*, and affords a special surface for muscular attachment. The outer surface of the supra-occipital is undulating and more or less convex. Its inner surface presents shallow depressions or fossæ, one of which (*cb*) is placed medianly above the foramen magnum, and lodges the middle portion of that part of the brain called the cerebellum.

The *basi-occipital* narrows somewhat as it advances forwards. Its upper surface exhibits a smooth concavity, the basilar groove, which supports that part of the nervous centres termed the "medulla oblongata."

Each part of the bone which bounds the foramen magnum on each side, *i.e.*, each *ex-occipital*, supports one of the condyles before

* Really made up of several distinct bones; but here, for the sake of simplicity and clearness, spoken of as one.

noticed. The condyles (*c*) are elongated convex prominences placed somewhat obliquely, converging forwards. The inner border of each is rough, for the attachment of one of the "check" ligaments. In front of each condyle is a perforation, the *anterior condyloid foramen* (1), which allows the hypoglossal nerve to pass out from the brain, while a canal (the hinder opening of which is a little within the margin of the foramen magnum) traverses the ex-occipital on its inner aspect. External to each condyle is an expanded process of bone called the *par-occipital process* (*p*), the front surface of which is applied to the posterior surface of the auditory bulla. The root of the par-occipital process forms the hinder boundary of the aperture of the skull through which the jugular vein comes out, which aperture is called the *foramen lacerum jugulare*, or *foramen lacerum posterius*.

Fig. 32.—Interparietal Bone.
A. Outer surface.
B. Inner surface.
a. Apex which passes forwards between the parietal bones.
b. Hinder margin.
c. Fossa for reception of part of brain.

A small triangular bone, the INTERPARIETAL, in the fully mature cat blends completely with the supra-occipital, but long remains a distinct ossicle. Its base is applied to the mid-part of the superior border of the occipital, while its sharp apex extends forwards between the parietals. It is strongly concave within (especially in the transverse direction) but is convex externally.

If this be counted as a part of the occipital that bone may be said to articulate above by its superior margin with the parietals, and below this, on each side, with the hinder margin of one of the temporal bones, while each par-occipital process (as before said) applies itself to the hinder end of one of the ordinary bullæ. The basi-occipital adjoins the hinder part of the bone next in front, namely the sphenoid.

§ **24**. The PARIETAL bone forms, with its fellow of the opposite side, the main part of the roof of the cranium. It would be quadrangular in figure but that its upper, hinder angle is rounded off, and it is strongly convex outwards, and concave within. The greatest convexity is termed the *parietal eminence* (*e*). Above this is a curved ridge convex upwards, marking the superior limit of the temporal fossa. Within, the parietal is marked by grooves for blood-vessels, and its upper margin is traversed by a longitudinal depression, which forms, with the help of the opposite parietal, a longitudinal wide and shallow groove for a blood receptacle called the longitudinal sinus. The two parietals are connected together above by the sagittal suture; each is connected by the lambdoidal suture with the interparietal, and with the supra-occipital. The parietal also articulates anteriorly (*f*) with the frontal by the

* It has not therefore been reckoned as a distinct bone in the list before given of the bones of the cranium and face.

coronal suture, and below with the temporal bone by a suture (*sq*) which is called *squamous*, because the margins of the bone it joins are so bevilled off that the temporal lies on the parietal like a scale. From the hinder margin of the parietal a plate of bone extends forwards at an acute angle, with a strongly concave free margin. This plate divides one part of the brain from another, and is an ossifica-

Fig. 33.—RIGHT PARIETAL BONE.

A. Internal surface.
B. External surface.
e. Parietal eminence.
f. Surface for articulation with frontal.
sq. Surface for temporal bone.
t. Tentorium

tion of a membrane called the tentorium, and described with the brain structures (*t*). The parietal is always a single bone.

§ 25. The remaining bones of the roof of the skull are the FRONTALS, which lie side by side in front of the parietals, and roof over the hinder part of the face as well as the front part of the cranium. The suture which divides them is termed the "frontal

Fig. 34.—THE FRONTAL.

A. External aspect.
B. Internal aspect.
f. Surface joining the other frontal.
fu. Outer wall of nasal fossa.
n. Nasal process.
op Orbital part of lateral plate.
tp. Temporal part of lateral plate.
p. Pre-orbital process.
po. Post-orbital process.

suture," and is the direct continuation forwards of the sagittal suture. The frontals together form a considerable, rather convex triangular expansion above, the outermost part of which is the post-orbital process (*po*) of the hinder part of the orbit; while behind this the frontal forms part of the temporal fossa.

But the greater part of each frontal is its lateral part (*op*), which descends from the outer margin, almost at right angles with its

upper surface, as an undulating plate (concave externally in front and convex behind) with a crescentic inferior margin. The hinder externally convex, part of this plate forms part of the tempora fossa; the anterior, externally concave, part of it forms the inner wall of the orbit, and (towards its front end) the outer wall of the nasal cavity.

Viewed internally, each frontal shows above, a flattened surface (*f*) for junction with its fellow of the opposite side; behind this is a deep concavity for part of the brain, and in front, a flattened and irregularly roughened surface (*fu*)—the outer wall of the hinder part of the nasal cavity.

Thus, the two frontals together have, when viewed from below, somewhat the figure of a bisected hour-glass. There is, behind, a large conical cavity (with the apex forwards) for the brain, while in front is a smaller conical cavity (with the apex backwards)—the nasal chamber. Consequently, when the two frontals are seen together from behind, they exhibit a deep median notch, open below, indicating the point of communication between the anterior and posterior conical cavities just mentioned, and situated at the point where each frontal is laterally constricted. This notch, in the perfect skull, is filled up by a bone called the ethmoid, which forms the hinder end of the nasal chamber. At its anterior end, each frontal bifurcates laterally into a sharp pointed "nasal process" (*m*) and a more obtuse "pre-orbital process" (*p*). Between these processes each frontal receives an ascending process of the maxillary bone. While the two nasal bones are received between the slightly diverging nasal processes of the two frontal bones (see Fig. 28).

Within the substance of the middle upper part of the bone is a cavity, more or less filled with air, called the *frontal sinus*, which cavity is prolonged out into the post-orbital process.

The frontals articulate behind, with the parietals; laterally, with the orbito- and ali-sphenoids, and sometimes also with the temporals below with the palatines, the maxillaries, the ethmoid, and the lachrymals; in front, with the maxillaries and nasals.

§ **26.** On each side of the hinder part and base of the cranium we find an exceedingly complex bone, called the TEMPORAL. When looked at externally it exhibits a very conspicuous oval opening (the *meatus auditorius externus*), which is the aperture (*me*) leading from without to the internal ear. From in front of this a bar of bone, the *zygomatic process* (*z*), arches horizontally forwards and outwards, and contributes, with the large plate of bone above it (*sq*), the squamous element of the temporal bone, or the "*squamosal*." This bony plate is convex without and concave within, and with a very rounded superior margin, which overlaps the lower part of the outside of the parietal bone above.

The zygomatic process is somewhat arched vertically, and is bevelled off at its distal end, which lies upon the malar bone. At its hinder end this process has beneath an elongated surface, concave from before backwards, and termed the *glenoid* surface (*g*).

In its natural state it is coated with cartilage, and serves for the articulation of the lower jaw. This surface is limited behind by a sharply descending bony plate—the *post-glenoid process* (*gp*). A ridge of bone is continued backwards from the hinder end of the zygomatic process, over the external auditory meatus, and is called the *posterior root* of the zygoma, the part supporting the glenoid surface, forming the *anterior root* of the zygoma.

The bone which bounds inferiorly the external auditory opening is that which forms the auditory bulla already spoken of. This is rounded, and smooth on the surface, and rather longer from before backwards than transversely. It is at first made of two parts: an external part, consisting of a crescentic plate of bone, broader in front than behind—the *tympanic* (so called on account of its

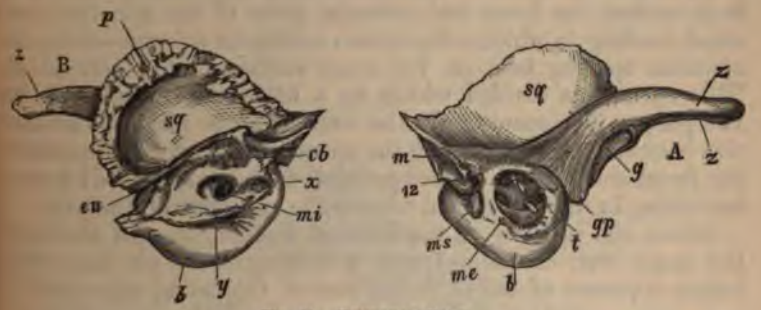


Fig. 35.—TEMPORAL BONE.

A. External view.
B. Internal view.
b. Inner and larger part of bulla.
cb. Cerebellar fossa.
eu. Eustachian opening.
g. Glenoid surface.
gp. Post-glenoid process.
m. Mastoid region.
me. Meatus auditorius externus.
mi. Meatus auditorius internus.
ms. Mastoid process.
p. Surface applied to parietal.
sq. Squamosal.
t. Outer and smaller part of bulla.
x. Aqueductus cochleæ.
z. Zygomatic process.
12. Stylo-mastoid foramen.
A process of the malleus is seen in Fig. A, extending downwards and forwards within the auditory meatus.

connexion with the drum of the ear)—and an internal, much wider part—the *ento-tympanic*—which forms all the rest of the bulla, which is naturally visible on the base of the skull.

Between the anterior end of the tympanic and the post-glenoid process is a narrow chink, termed the *fissura Glaseri*, which transmits the chorda tympani nerve.

At the hinder end of the tympanic, beneath the posterior end of the posterior root of the zygoma, is an opening (12), called the *stylo-mastoid* foramen, which gives exit to the facial nerve. Immediately below and within this foramen there is a small pit in the tympanic, at the bottom of which a minute cylindrical ossicle, called the *tympano-hyal*, may be detected, which serves to give attachment to the uppermost and cartilaginous portion of the anterior, or lesser cornu of the hyoid (Fig. 46, *t**).

The only remaining part of the temporal bone visible externally is a very small and narrow triangular tract, which extends upwards

and backwards (its apex being above) from above the stylo-mastoid foramen and behind the posterior root of the zygoma. It is rough externally, and forms the lower part of the lambdoidal ridge, the upper part of which is formed by the occipital bone. Opposite the posterior root of the zygoma it adjoins the par-occipital process, and below that point of junction it narrows into a nipple-shaped process applied externally to the tympanic, and descending, immediately behind the stylo-mastoid foramen, to the pit for the tympano-hyal. This triangular tract is the *mastoidal* region (*m*) of the temporal bone, and the process just described is the *mastoid process* (*ms*).

On its inner aspect, below and behind the squamous part (*sq*), the temporal bone exhibits a triangular irregularly-shaped mass of very dense osseous tissue. This is the *petrous* part of the temporal bone, or the "*petrosal*." The petrous and mastoidal portions of the bone enclose the inner and essential parts of the ear, the internal canal leading to which—the *meatus auditorius internus*—is the conspicuous opening seen on the inner surface of the petrosal (*mi*). This opening is divided within by a horizontal bony lamella into two parts. The openings for the auditory nerve filaments are below this horizontal lamella, while the opening above it gives entrance to the facial nerve, which thence proceeds to the stylo-mastoid foramen, traversing in its way a canal termed the *Aqueduct of Fallopius*.

Above the opening of the internal auditory meatus there is, on the inner wall of the petrosal, a depression or pit (*cb*), (which lodges a process of the cerebellar part of the brain) surmounted by a prominence which indicates the place of the anterior vertical semi-circular canal of the internal ear. Below and in front of this prominence is a small foramen, the *hiatus Fallopii*, which transmits the superficial petrosal nerve, and leads back into the Aqueduct of Fallopius already mentioned.

Just behind the shallow depression above mentioned, and close to the posterior margin of the petrosal, is a small vertically elongated opening, called the *aquæductus vestibuli*. A still smaller aperture placed close to and directly behind the internal auditory opening (*x*) is the *aqueductus cochleæ*. Both these openings transmit small veins of the internal ear.

Between the anterior part of the petrosal bulla and the alisphenoid is a largish opening (*eu*), which is that of the *Eustachian tube*—a channel serving to convey air from the mouth to the ear. The inner part of the canal is incompletely partitioned off by a small bony lamella—(the *processus cochleariformis*). This rather considerable Eustachian aperture is naturally roofed over and covered by a backward expansion of the alisphenoid. On the inner side of it, at the hinder portion of the junction of the squamosal and petrosal portions of the temporal bone, on its inner surface, is a groove which receives a venous canal, namely one of the two branches into which the median venous channel (before noticed as passing along beneath the median junction of the parietals) divides as it descends. This groove may lead into a canal opening

y a foramen just behind the post-glenoid process—a *post-glenoid foramen*. This, however, is generally absent.

The margin of the petrosal, above the cerebellar fossa and internal meatus, developes a bony ridge, which unites with the tentorial plate, before described as passing downwards and forwards from within the parietal.

The cavity of the bulla is almost completely divided within into two very unequal parts by a bony septum which ascends from the

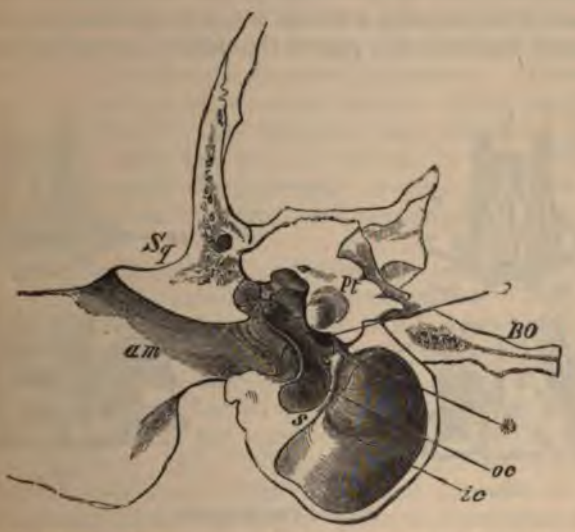


Fig. 36.—VERTICAL SECTION OF THE AUDITORY BULLA OF THE TIGER (*Flower*).

am. Meatus auditorius externus.
BO. Basi-occipital.
e. Eustachian canal.
ic. Inner chamber of bulla.
oc. Outer chamber of bulla.
pt. Promontory of petrosal.
s. The septum.
Sq. Squamosal.
t. Tympanic ring.
* The aperture of communication between the two chambers.

floor of the bulla. The outer and anterior chamber is much the smaller. It is the true tympanic chamber, and has on its outer wall a horseshoe-shaped prominence and groove—the tympanic ring—to which the tympanic membrane (or membrane of the drum of the ear) is attached. It also contains three very small and irregularly-shaped bones: (1) the *malleus*; (2) the *incus*; and (3), the *stapes*, which stretch across from the inside of the tympanic membrane to the opposite wall of the petrosal, and are known as the auditory ossicles—*ossicula auditûs*—and will be described together with the organ of hearing. A long process (mnubrium) of the malleus is conspicuous (see Fig. 35, A), passing downwards and forwards from the upper part of the tympanic cavity. Also the Eustachian tube (*e*) opens into this same outer chamber, superiorly and anteriorly, while towards its hinder margin are two holes placed one above another,

situated in the wall of the petrosal, opposite the tympanic membrane. The upper, more anterior, and smaller of these is called the *fenestra ovalis*, the lower and more posterior is the *fenestra rotunda*. It is through these that the really internal ear (a complex membrane which is lodged in a correspondingly complex bony envelope within the petrosal) is placed in communication with the exterior (Fig. 137).

The internal, posterior, and much larger chamber, is entirely closed, save that a small opening (Fig. 36, *) is left between the hinder part of the top of the septum close to the fenestra rotunda, so that this fenestra may be said to open into the inner as well as the outer chamber.

In front of the fenestra rotunda is a bony prominence, caused by the presence within it of a part of the internal ear called the cochlea.

Fig. 37.—The Sphenoid.

A. Under surface.
B. Upper surface.
ac. Anterior clinoid process.
as. Ali-sphenoid.
bs. Basi-sphenoid.
cp. Clinoid plate.
hp. Hamular process.
os. Orbito-sphenoid.
p. Ethmoidal process.
pf. Pterygoid fossa.
pr. Pre-sphenoid.
pt. Pterygoid plate.
r. Rostrum.
7. Optic foramen.
8. Foramen rotundum.
9. Foramen ovale.
The anterior and posterior portions are represented as separated, and thus the sphenoidal fissure (which is defined by their junction) is not indicated.

This prominence is called the "promontory" (*pf*). Above it, and in front of the fenestra ovalis, is a pit, or fossa, within which arises a small muscle called the *Stapedius*.

The temporal bone, as has been said, is really made up of several bones anchylosed together, which were at first distinct.

Thus we have (1) the squamosal (*sq*), with its zygomatic process (*z*); (2) the tympanic, which forms the outer chamber of the bulla (*t*); and (3) the entotympanic, which forms the inner chamber of the bulla (*b*); and (4) the minute tympano-hyal. Besides these four elements three other distinct ossifications exist and coalesce to form the petrous and mastoid portions of the temporal bone, and are distinguished by their diverse relations with parts

he internal organ of hearing. Continuing our enumeration, we have (5) an ossification which gives rise to the upper part of the petrous portion (that which is visible inside the skull), and to part of the mastoid. It forms the upper margin of the fenestra ovalis, and is especially related to the anterior vertical semicircular canal. It is called the *Pro-otic*. We have next one (6) which gives rise to the lower part of the petrosal (that concealed by the auditory bulla), which forms the lower part of the fenestra ovalis, and surrounds entirely the fenestra rotunda. It is called the *opisthotic*. Lastly, we have an ossification (7) which gives rise to the mastoid process, and which is developed upon the hinder part of what will be hereafter described as the posterior vertical semicircular canal of the internal ear. This ossification is named the *epiotic*. The whole of these, *i.e.*, the petrous and mastoid portions taken together, are known as the "*periotic*." The temporal bone articulates with the occipital behind, with the parietal above, in front, with the sphenoid, and (through the zygomatic process) with the malar. The apex of the petrosal is wedged in between the basi-occipital and the sphenoid.

§ **27**. The SPHENOID is also a very complex bone, and consists of two distinct parts,* one anterior, the other posterior. The posterior sphenoid may be first described. This is the central bone of the base of the skull, and its median part, or body, called the *basi-sphenoid* (*bs*), joins the basi-occipital behind. It has on the middle of its upper surface a shallow pit called the *sella turcica*, or *pituitary fossa*, because it receives and supports an appendage of the brain, called the "pituitary body." This fossa is bounded behind by a small plate of bone (*cp*), which is inclined forwards as well as upwards, and the hinder surface of which is continuous with the upper surface (or basilar groove) of the basi-occipital. The plate is called the *clinoid plate*, and its two upper angles are produced outwards into prominences termed the *posterior clinoid processes*. Beneath, the basi-sphenoid is nearly flat, and becomes narrower as it advances forwards. Its structure is solid, not containing air-cavities.

On each side of the basi-sphenoid there projects outwards a large crescentic plate of bone, concave above from behind forwards (*as*), which is its longest dimension. This is the *ali-sphenoid*, or great wing of the sphenoid, and it forms the side wall of the cranium, immediately in front of the squamosal and auditory bulla. Its upper margin is concave, the lower margin of the squama of the temporal bone being received into its concavity. Its hinder end overlaps the petrosal (helping to close the large aperture in which the Eustachian tube ends), and meets the anterior end of the ossified tentorial plate of the parietal. Its anterior end ascends behind the frontal, towards or to, the parietal. The ali-sphenoid is perforated on each side

* It is described here as a single bone, because it is so considered in human anatomy.

by two foramina. The hinder and outer of these, which is the larger, is the *foramen ovale* (9), and transmits the third division of the fifth nerve. Immediately in front of this is a smaller opening the *foramen rotundum* (8), which transmits the second division of the fifth nerve. Immediately in front of this again is a large and deep notch which, in the complete skull, is bounded in front by the hinder margin of the anterior sphenoid, and so is converted into a foramen. This aperture is called the *sphenoidal fissure*. It transmits the first division of the fifth nerve, together with the nerves of the orbit to be hereafter described. The upper surface of the posterior sphenoid exhibits, on each side of the sella, a faintly-marked groove (for a cranial artery) ending posteriorly in a notch. The piece of bone immediately external to such groove and notch (between the basi-sphenoid and the greater part of the ali-sphenoid) is called the *lingula sphenoidalis*, and is at one time of life distinct.

Extending forwards much in front of the basi or ali-sphenoids are two complex bony plates which extend forwards and downwards from the junction of the basi- and ali-sphenoid on each side, and also join the palatine bones in front. Each of these is termed a *pterygoid* plate (*pt*) and its flattened upper surface articulates with the under surface of the anterior sphenoid. The under surface of this flattened part forms part of the basis cranii, and towards its outer margin a lamellar process of bone projects downwards, having at its hinder end a curved sharp-pointed process (the *hamular process*) arching backwards and somewhat downwards and outwards. Externally to this hamular process, the pterygoid plate sends outwards another small, more or less lamellar process. The very small space included between this last and the hamular process, is called the pterygoid fossa (*pf*), and there is of course one on each side of the skull. The very considerable space included between the two pterygoid plates is called the *meso-pterygoid fossa*, and that is single and median. The part which immediately supports and forms each hamular process, is originally a distinct bone, called the *pterygoid bone*.

The anterior sphenoid is much longer in proportion to its width than is the posterior, but like it consists of a median part with two wings or lateral expansions. The median part, called the *pre-sphenoid* (*ps*) joins the basi-sphenoid behind. It is not solid, but contains a great air-cavity, divided by a median septum into two "*sphenoidal sinuses*," which open widely at their anterior end (the bone expanding anteriorly into two ethmoidal processes (*p*)), to embrace the lower posterior angle of the ethmoid. The pre-sphenoid bears a median inferior ridge, the *rostrum* (*r*), which is visible between the inner margins of the two pterygoid plates of the posterior sphenoid. The upper surface of the *vomer* is attached to the anterior part of the rostrum. The upper surface of the pre-sphenoid is much elongated. Its anterior two thirds support the olfactory lobes of the brain and are convex from before backwards, but slightly concave from side to side. Its posterior third (separated from the more anterior part by two foramina) is slightly convex, and supports the optic nerves (where

they unite in a commissure) on what is termed the *olivary eminence*. This eminence bounds anteriorly the pituitary fossa, and at each side of its hinder margin a minute process is to be detected. These are the *anterior clinoid processes* (*ac*). On each side of the presphenoid there projects upwards and outwards a short triangular plate of bone (*os*) called the orbital wing of the sphenoid, or *orbito-sphenoid*. This is pierced at its root by a considerable opening (7), the *optic foramen*, which transmits the nerve of sight. The orbito-sphenoids form the anterior lateral part of the floor of the cranium, projecting upwards and outwards between the frontal in front, and the ali-sphenoid behind.

The optic foramen opens immediately in front of, and above, the sphenoidal fissure and the round and oval foramina, all of which open into the bottom and hinder part of the orbital and temporal fossæ (see Fig. 46, 6, 7, 8, and 9).

The sphenoid considered as one whole unites with the basi-occipital, temporal, and parietal bones behind; in front, with the ethmoid, frontals, vomer, and palatines.

§ 28. The ETHMOID, or sieve-like bone—formed of very delicate lamellæ very much contorted—is an exceedingly complex structure which fills up the space (*incisura ethmoidalis*) left between the constricted parts of the two frontals, and thence extends downwards and forwards into the upper parts of the nasal chamber, which it almost entirely occupies. It is thus placed between the cranium and the face, extending forwards between the orbits and forming the hinder wall of the nasal cavity. It consists of a median and two lateral portions. The middle part is a simple vertical lamella of bone—the *mesethmoid* (Fig. 49, *me*), which extends forwards from the middle of the anterior surface of another transversely extended, obliquely ascending plate called, from the number of its foramina, "*cribriform*." From each side of the anterior surface of this cribriform plate (and on each side, therefore, of the mesethmoid), a mass of delicate and excessively plicated osseous tissue extends forward, bearing the name of the *lateral ethmoid* or *ethmo-turbinal* (Figs. 49 and 50, *et*). The mesethmoid has a free margin on every side except where it is anchylosed to the cribriform plate behind. Its superior margin is adjacent to the lower margin of the median deflected portion of the frontal, and to the inferior margin of the nasal. Its inferior margin dips down between the ascending bifurcating lamellæ of the vomer. The mesethmoid is much longer from before backwards than it is high.

The ETHMO-TURBINAL rises (Fig. 50, *et*) on each side considerably higher than the upper margin of the mesethmoid, and into the chamber formed by the nasal and nasal process of the frontal on the inner side, and the preorbital process of the frontal on its outer side. It also descends slightly below the inferior margin of the mesethmoid, and joins the ascending, diverging, superior, and posterior part of the vomer.

The folds and grooves of the ethmo-turbinal or lateral ethmoid proceed forwards and slightly downwards and outwards.

Close to the upper margin of the anterior lateral aspect of t lateral ethmoid is a small smooth, nearly triangular, surface, wh appears on the inner wall of the orbit between the lachrymal, t frontal, and the palatine. It is called the *os planum*; the lame which spring from the cribriform plate are also connected with t os planum.

§ **29**. The anterior inferior portion of the ethmoid mass (Figs. and 50, *mt*) is really a separate bone, called MAXILLO-TURBINAL. T consists of other plicated delicate lamellæ which proceed from t inner surface of the maxilla. The grooves and folds of this m of lamellæ all proceed upwards and forwards.

The passage between this maxillo-turbinal and the upper surf

Fig. 38.—THE RIGHT MAXILLA.

A. External aspect.
B. Internal aspect.
m. Malar process.
n. Nasal process.
a. Sutural ridge.
t. Tuberosity.
2. Infra-orbital foramen.

of the roof of the mouth is called the *inferior meatus* of the n The passage between this and the maxillo-turbinal, and the eth turbinal, is called the *middle meatus* of the nose.

A passage which traverses the ethmo-turbinal on a line with inferior margin of the nasal bones is called the *superior meatu* the nose.

The mass of the ethmoid lies between the nasals and fron above; the orbital plate on the frontal, the presphenoid, palatine, and the lachrymal on each side, and by the presphen the vomer, and the palatines below.

THE BONES OF THE FACE.

§ **30**. Having described those bones which enter into the position of the brain-case, it remains to describe those of the namely, the maxillary and pre-maxillary bones, the nasals, malars, the lachrymals, the palatines, the vomer, the mandible, the hyoid bone. The turbinal bones or maxillo-turbinals already been noticed in describing the ethmoid, of which they to form the anterior, inferior portion.

The *maxillary* bone, or MAXILLA, is the largest bone of the face, forming as it does, with its fellow of the opposite side, the main part of the upper jaw, and supporting all the upper teeth, except the incisors. It also contributes to form the cheek, the orbit, the nasal passage, and the palate. The two maxillary bones do not meet in the middle line below the anterior nares, but each sends up a prolongation—the *nasal process*—(*n*) to the frontal. This process bounds the inner side of the orbit anteriorly, and by its anterior and upper margin joins the nasal bone. Its inner surface exhibits a vertical groove, which is made into a canal by the help of the lachrymal bone. There is also on the inner surface a more or less horizontal ridge which serves to give attachment to the maxillo-turbinal. The superior, external part of the maxilla sends a process outwards (beneath the orbit), which joins the malar bone, and is therefore called the *malar process* (*m*). Superiorly the maxilla exhibits a smooth, horizontal surface (Fig. 28, *m*) which forms the floor of the orbit, and is called the *orbital plate*. It is traversed, from before backwards, by a groove ending anteriorly in a large foramen (2), which transmits the second branch of the fifth nerve, and is called the *infra-orbital fifth nerve*.

On the outer surface of the maxilla, in front of the malar process, is a slight concavity termed the "*canine fossa*." Behind the malar process the outer surface of the maxilla has a slightly enlarged portion called the *tuberosity* (*t*), which is perforated by small foramina for the superior dental nerves and arteries. The lowest part of the maxilla is termed the *alveolar border*, and is hollowed out into the *alveoli*, or sockets, for the teeth. From this border the maxilla sends inwards a large horizontal process called the *palatine plate*. This is smooth and transversely concave above, but more or less roughened and grooved below. It rises somewhat where it meets its fellow of the opposite side in a sutural ridge (*o*), which supports the vomer. The anterior margin of the palatine plate is slightly, its posterior margin is deeply, concave.

The maxilla articulates with the pre-maxilla and nasal in front, with the frontal above, and with the lachrymal, malar, and palatine behind.

§ **31.** The PRE-MAXILLA is a very small bone placed in front of the maxilla, and joining, anteriorly, its fellow of the opposite side—the two together forming the anterior termination of the upper jaw. Each pre-maxilla consists of two unequal pointed processes diverging, one upwards and one backwards, from a thickened anterior portion which is the alveolar margin, and supports three incisors.

The ascending, and much the larger, process (*m*) mounts up in front of, and adjacent to, the anterior margin of the ascending nasal process of the maxilla as far as the nasal, insinuating itself between that bone and the maxilla. The two pre-maxillæ bound the anterior nares below and on each side, the nasals bounding the anterior nasal opening above.

From the inner side of the pre-maxilla the slender s palatine process (*p*) extends backwards, in contiguity with i of the opposite side, till it meets the anterior margin of the plate of the max notch is thus for tween this backwa tending process more external po the pre-maxilla, a notch is converted foramen by the plate of the maxill it. This is the *anter tine*, or *incisor foramen*, which is the anterior termination *anterior palatine canal* transmitting the naso-palatine nerve.

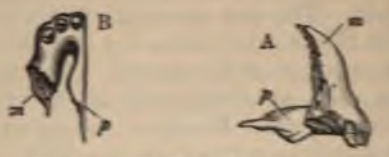


Fig. 39.—Right Pre-maxilla.
A. Inner aspect.
B. Ventral aspect.
m. Ascending process.
p. Palatine process.

§ **32.** The MALAR is a rather small, lamellar bone which f most prominent part of th the outer inferior margin of t and the anterior part of the It is in the form of a quadrangular plate, convex concave within, and with processes. Its anterior margin (*m*) rests on the ma cess of the maxilla. Its superior margin forms part rim of the orbit. Its portion, or zygomatic proc applied beneath the lower of the zygomatic process squamosal. Immediately of the anterior end of that the malar developes a pos process (*p*) which mounts u backwards, and inwards, but not to, the post-orbital of the frontal. The postero-

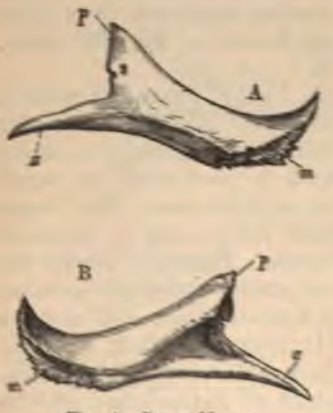


Fig. 40.—Right Malar.
A. External view.
B. Internal view.
m. Surface for malar.
p. Post-orbital process.
z. Zygomatic process.

margin of the malar is strongly concave.

§ **33.** The NASALS are two elongated, small triangula placed side by side above the anterior nares in front of the Each is considerably extended vertically towards its hin (B and C), and somewhat less extended transversely tow distal end (A). Its anterior margin is concave, its external being produced forwards much beyond its internal angle.

The inner side of the vertically-expanded part of the bon flat, and applied to its fellow of the opposite side. Its outer su is concave, and receives the nasal process of the frontal in specially destined for it (*n*). The nasals join the frontals, and pre-maxillæ, and form the superior margin of the anteri

§ 34. The LACHRYMALS are also very small bones, one of which is placed at the anterior part of the inner wall of each orbit (Fig. 46, *la*), having the frontal above, the os planum behind, the nasal pro-

Fig. 41.—RIGHT NASAL.

A. External surface.
B. Surface turned towards the other nasal.
C. Outer lateral surface.
a. External angle.
n. Fossa for nasal process of maxilla.

Fig. 42.—RIGHT LACHRYMAL.

A. Outer surface.
B. Inner surface.

cess of the maxilla in front, and the orbital plate of the same bone below. Each lachrymal is marked by a vertical groove and notch (*n*), which, by joining the similarly directed groove on the posterior side of the nasal process of the maxilla, forms a foramen and canal, called "lachrymal," which leads from the orbit to the nasal cavity.

§ 35. The PALATINES are two bones which by their median junction behind the maxillæ, complete the bony palate, which, as we have already seen, is partly formed by the palatine plates of the

Fig. 43.—RIGHT PALATINE BONE.

A. Ventral aspect.
B. Cranial, or dorsal aspect.
C. Anterior aspect.
a. Ascending plate.
h. Horizontal plate.
3. Palatine foramen.
5. The spheno-palatine foramen.

maxillæ. The palatine is irregular in shape, consisting mainly of two unequal plates, which are inclined inwards towards each other at an acute angle—one ascending, one horizontal. The bone is wedged in between the maxilla in front and the pterygoid behind. It bounds the meso-pterygoid fossa laterally, and the hinder part of the nasal cavity inferiorly; and it forms part of the floor and of the inner wall of the orbit.

The *ascending plate* (*a*), which is the main portion of the bone, is

more than twice as long as it is high; but its anterior half is higher than its posterior, and presents two foramina, one of very considerable size, the *spheno-palatine*, foramen directly over a very much smaller *posterior palatine foramen* (Fig. 43, B). More than the hinder half of the inferior margin of this ascending plate is smooth, free, and concave; the rest of that margin joins the maxilla. Its hinder end joins the pterygoid. The hinder half of its superior margin joins the orbito-sphenoid and the pre-sphenoid, to which latter the concavity its of upper margin is adjusted. Its more anterior portion is applied against the outer side of the ethmo-turbinal. The *horizontal lamella* (*h*) projects inwards (from the anterior two-thirds of the inferior margin of the ascending lamella), and joins its fellow of the opposite side in the middle line, and there also joins the inferior margin of the hinder part of the vomer. Its anterior margin is convex, and adjoins the hinder margin of the palatine plate of the maxilla of the same side. Its hinder margin is concave and free, forming the posterior limit of the bony palate and the anterior boundary of the meso-pterygoid fossa. The posterior palatine foramen (3) very near to, or at, its anterior margin.

The palatine articulates with the maxilla, the vomer, the lachrymal, the os planum, the orbital plate of the frontal, the pre-sphenoid, and the orbito-sphenoid.

§ **36.** The VOMER (Fig. 49, *v*) is a single, thin, median bone grooved above, and extending down vertically from the basi-sphenoid

Fig. 44.—INSIDE OF RIGHT HALF OF MANDIBLE.

an. Angle.
c. Coronoid process.
cr. Ascending ramus.
hr. Horizontal ramus.
sy. Symphysis.
y. Condyle.
14. Inferior dental foramen.

and ethmoid, to the upper surface of the bony palate, thus completing a vertical median partition between the nostrils. It is a very long and narrow bone, very obliquely quadrangular in shape. Its hinder portion, however, expands horizontally, to support and unite with the inferior and hinder parts of the ethmo-turbinals—its hinder end under-lapping the anterior part of the pre-sphenoid. In front of the expanded part, the grooved upper surface of the vomer receives within its groove the lower edge of the mesethmoid; while, still more anteriorly, the septal cartilage of the nose is received within the same groove. The lower margin of the vomer unites

with the palatine plates of the maxillæ and palatines. Its posterior margin is free, and forms the hinder end of the lower part of the internasal septum.

§ **37.** The skeleton of the lower jaw, or MANDIBLE, consists of two bones, which meet together in front at an acute angle. Each bone, *i.e.*, each half of the mandible, consists of two parts—its hinder, vertically expanded portion, being called the *ascending ramus* (*ar*), while the rest is named the *horizontal ramus* (*hr*). The horizontal ramus is almost of the same depth throughout, and slightly curved—its upper margin being concave, and its lower margin convex. The latter is smooth and rounded, but the upper edge is festooned by unequal cavities, forming sockets for the lower teeth. The place of junction of the two horizontal rami is called the *symphysis* (*sy*), and presents a very rough surface. The horizontal ramus begins to expand into the ascending ramus immediately behind the last tooth, and becomes a triangular plate of bone, concave externally, and with three prominences, separated by two concavities, on its hinder margin.

The highest of these prominences (which is also the highest part of the mandible) is called the *coronoid process*, and is a vertical plate of bone (*c*). The second prominence (separated from the preceding by a considerable interval) is the *condyle* of the mandible, and is a transversely-extended convex articular surface (*y*), destined to fit into the glenoid fossa of the temporal bone. The piece of bone which immediately supports the condyle is termed the *neck*. The third and lowest prominence (separated from the condyle but by a narrow interval) is termed the angle (*an*), and is a small, vertically-extended process, on a line with the inferior margin of the horizontal ramus.

The coronoid process rises even a little more above the condyle than does the latter above the angle, and has inserted into it the temporal muscle.

The deep fossa outside the ascending ramus (Fig. 46, *ar*), the ridge beneath it and the angle, have inserted into them a muscle, called the masseter. The symphysis is convex and very oblique, being inclined strongly backwards as well as downwards.

The outer surface of the horizontal ramus is convex, its inner surface is flattened. On the inner side of the ascending ramus, below the level of the condyle, is a considerable foramen, called the *inferior dental* (14). This leads into the "dental canal," down which the dental nerves and vessels pass.

At the more anterior part of the outer side of the horizontal ramus are a pair of small foramina (Fig. 46, [13]), called the *mental foramina*. They transmit branches of the inferior dental nerve and artery.

Behind the symphysis, towards its lower end, is a small depression serving for the insertion of the digastric muscle.

§ **38.** The HYOID apparatus is a complex structure, consisting of two long jointed bony bars (*t** to *ch*), "the *anterior cornua*," and two short unjointed bony bars (*th*), "the *posterior cornua*"—both an

anterior and a posterior cornu springing from either end of a median bony bar, "the *body of the hyoid*" (*bh*), or *basi-hyal*. The *basi-hyal* is a transversely-extended flattened bar of bone, which, in the natural condition, is placed above the front part of the thyroid cartilage of the larynx (T). At the front margin of each end is attached a short cylindrical bone (about half the length of the basi-hyal), called the *cerato-hyal* (*ch*). To the end of this, is again annexed another long bone, called the *epihyal* (*eh*), at the end

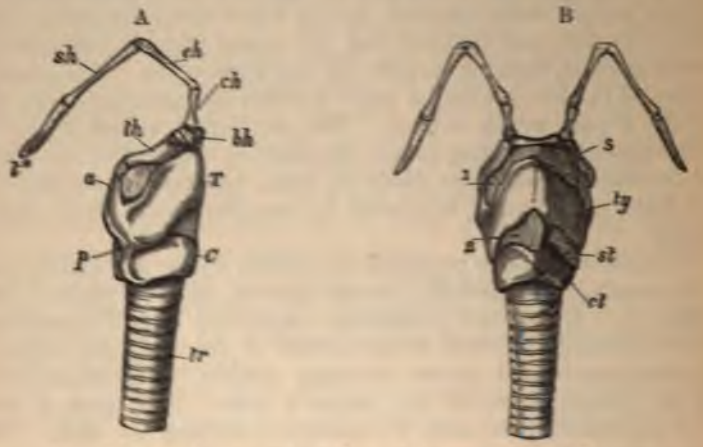


Fig. 45.—Hyoid Apparatus, with Larynx and upper part of Trachea.

A. Ventral view.
B. Lateral view.
a. Connexion of thyrohyal with thyroid cartilage.
bh. Basi-hyal.
ch. Cerato-hyal.
cr. Crico-thyroid muscle.
eh. Epihyal.
s. Sterno-hyoid muscle cut short.
st. Sterno-thyroid muscle cut short.
t*. Cartilage of tympano-hyal.
th. Thyro-hyal.
ty. Thyro-hyoid muscle.
tr. Trachea.
p. Crico-thyroid ligament.
C. Cricoid cartilage.
T. Thyroid cartilage.
1. Thyro-hyoid membrane.
2. Crico-thyroid membrane.

of which is another cylindrical bone, called the *stylo-hyal* (*sh*), which is again longer than the epihyal. At the end of the stylo-hyal is a cylindrical cartilage (*t**), which is the cartilaginous continuation of that minute cylindrical bone, the tympano-hyal, which becomes anchylosed into the pit before noticed as existing in the auditory bulla immediately on the inner side of the stylo-mastoid foramen.

This chain of ossicles, with its fellow of the opposite side, together constitute the anterior cornua. (See also Fig. 46.)

At the hinder margin of each end of the basi-hyal (just below the attachment of the cerato-hyal) is a cylindrical bone attached, called the *thyro-hyal* (*th*). This is about as long as the basi-hyal, and shorter than the stylo-hyal. It is connected by membrane with the upper border of the lateral part of the thyroid cartilage of the larynx.

§ 39. On examining in greater detail than heretofore, and with that ledge of its component bones which the foregoing pages may have

afforded, we find, when the *outside of the* SKULL IS VIEWED IN FRONT, (Fig. 30) the following parts:—Below, the maxillæ and pre-maxillæ form the alveolar borders. The curved outline of the vertex (*f*) is formed by the frontals. The two large and conspicuous orbits are bounded below by the zygomata, from which the malar post-orbital processes (*pj*) ascend, and approach the descending (*pf*) post-orbital processes of the frontals. Between the orbits there is a broadish bony expanse (formed by the frontals, nasals, and maxillæ), except inferiorly where the heart-shaped aperture of the anterior nares is situated—only bounded below by the horizontal processes of the pre-maxillæ (*pm*). The nasal bones (*n*) ascend rather higher than do the nasal processes of the maxillæ. On each side of the anterior nasal opening, and just beneath the margin of the lower boundary of the orbit, is the large opening of the infra-orbital canal (2).

The parts which project furthest outwards are the zygomatic processes of the temporal bones (*z*).

At the back of each orbit is seen the convex side-wall of the skull (*f*) projecting into it, but the foramina which open into the bottom of the orbit are hidden from this point of view.

On examining the BASE OF THE SKULL (see Fig. 29), we find in front the alveolar margin (describing an acute but truncated angle, with its truncated apex forwards) surrounding the bony palate (*m* and *p*), which extends a little further backwards than do the teeth. The anterior end of the bony palate is formed by the pre-maxillæ (*pm*), between which and the maxillæ are the two large anterior palatine foramina. At above the place of junction of the palatine plates of the maxillæ with the palatines, there are on each side one or two much smaller foramina, termed the *posterior palatine foramina* (3).

Behind the palate, we have, in the middle, the meso-pterygoid fossa (*ps*) (into which the posterior nares open), bounded laterally by the palatines and pterygoids (*pt*). External to this, is on each side the wide vacant space of the temporal fossa enclosed by the zygoma.

Behind the meso-pterygoid fossa the *basis cranii* presents a straight surface of about equal width, formed successively by the under surfaces of the basi-sphenoid (*bs*) and basi-occipital (*bo*), and terminated posteriorly by the occipital condyles (*oc*) and foramen magnum (*fm*). At the hinder and outer side of each pterygoid bone is the minute pterygoid fossa, external to, and partly hidden by, the hinder part of which is the foramen rotundum (8); while the foramen ovale (9) is again just behind, and external to, the foramen rotundum. External to the foramen ovale, and on a line with it, is the glenoid fossa for the lower jaw (*g*), bounded posteriorly by the post-glenoid process behind, and internal to which is the fissura Glaseri. Behind this again, is the large and swollen auditory bulla (*b*), at the anterior end of which, immediately behind the foramen ovale, is the anterior aperture of the Eustachian tube (10), and a very small aperture called the *foramen lacerum anterius*, leading into the inside of the cranium. Between the inner hinder part

of the auditory bullæ and the basi-occipital is the large and conspicuous *foramen lacerum posterius* (11), which transmits the jugular vein and the glosso-pharyngeal, par vagum and spinal accessory

Fig. 46.—Side view of the Cranium, the Lower Jaw and the Hyoidean Arch being somewhat detached.

a. (Just above 6 and 7). Ali-sphenoid.
ae. Meatus auditorius externus.
an. Angle of mandible.
ar. Ascending ramus.
b. Auditory bulla.
bh. Basi-hyal.
c. (Of cranium) occipital condyle.
c. (Of mandible) coronoid process.
ch. Cerato-hyal.
eh. Epi-hyal.
f. Frontal.
hr. Horizontal ramus of mandible.
ip. Inter-parietal.
j. Malar (or jugal).
la. Lachrymal.
m. Maxilla (its nasal process).
ms. Mastoid process.
n. Nasal.
os. Orbito-sphenoid.
p. Parietal.
pa. Palatine.
pt. Pterygoid.
pm. Pre-maxilla.
s. Squamosal.
sh. Stylo-hyal.
so. Supra-occipital.
t*. Cartilage of tympano-hyal.
th. Pit of tympano-hyal.
y. Apex of lambdoidal ridge.
z. Zygoma.
1. Infra-orbital foramen.
6. Optic.
7. Sphenoidal fissure.
8. Foramen rotundum.
9. Foramen ovale.
12. Stylo-mastoid foramen.
13. Mental foramina.
The spheno-palatine foramen is shown just above, and in front of *pa*, close to posterior margin of anterior end of zygoma.

nerves. This foramen is bounded behind by the exoccipital (*pp*), which is perforated by the anterior condyloid foramen transmitting the hypoglossal nerve. At the anterior wall of the foramen lacerum posterius is the opening of a very small canal (for the minute internal carotid artery) which runs forwards (between the basi-occipital and basi-sphenoid on one side, and its auditory bulla on the other) to open inside the cranium beside the sella turcica.

hind the post-glenoid process, the large meatus auditorius externus to be seen, and close behind it the stylo-mastoid foramen (12), mediately internal to which is the pit for the tympano-hyal, close contiguity to which again the small mastoid process is seen escending (*ms*).

Looking at the SIDE OF THE SKULL, we see above, the evenly-rched outline of the cranium and face (formed by the nasals, rontals, and parietals), with the straight but inclined line of the ciput behind. The base of the skull is almost straight, though

Fig 47.—SKULL VIEWED, FROM BEHIND WITH THE LOWER JAW DETACHED.

a. Angle of mandible.
b. Auditory bulla.
bo. Basi-occipital.
c. Coronoid process of mandible.
f. Condyle of mandible.
fm. Foramen magnum.
g. Glenoid surface.
gp. Post-glenoid process.
ip. Inter-parietal.
l. Lambdoidal ridge.
ms. Mastoid process.
oc. Occipital condyle.
p. Parietal.
pf. Post-orbital process of frontal.
pj. Post-orbital process of malar.
so. Supra-occipital.
sq. Squamosal.
z. Zygoma.
14. Inferior dental foramen.
The par-occipital process is seen (on each side) between the occipital condyle (*oc*), and the auditory bulla (*b*), and above the latter.

e middle part does not descend so much as does the alveolar rgin in front or the auditory bulla behind. The anterior end of skull is formed by the small premaxilla (Fig. 46, *pm*), which nds and joins the nasal (*n*). Behind this the wide nasal process of maxilla (*m*) is interposed in front of the orbit, the anterior margin hich slopes upwards and backwards. Just inside the lower part hat margin is the lachrymal bone (*la*) with its foramen; behind ch is the os planum. The frontal (*f*), palatine, pre-sphenoid, and to-sphenoid (*os*), form the inner wall of the orbit. Just below front part of the inferior margin of the orbit is the infra-orbital men (2). Behind, and on a level with this (within the orbit),

are the spheno-palatine foramen and the posterior palatine canal. The orbit is seen to be bounded below by the maxilla, on which the malar (*j*) is imposed, and sends up its post-orbital process towards but not to, the descending post-orbital process of the frontal. The lower margin of the malar is strongly concave, and the zygomatic process of the squamosal (*z*) is also strongly concave below, the zygoma being much arched upwards as well as outwards.

At the bottom of the orbit we find, one behind the other, the optic foramen (6), sphenoidal fissure (7), round foramen (8), and the foramen ovale (9); while the side wall of the cranium sends outwards a marked but blunt projection (formed principally by the ali-sphenoid), which runs upwards towards the post-orbital process of the frontal, and would, if it were greatly enlarged, more or less enclose the orbit posteriorly.

Beneath the hinder end of the zygoma, is the glenoid fossa and post-glenoid process; and behind this, the auditory bulla (*b*) with its external meatus (*ae*), the stylo-mastoid foramen (12), the pit for the tympano-hyal (*t*), and the mastoid (*ms*) and par-occipital processes. Thence, the lambdoidal ridge (*y*) runs upwards and backwards, while behind and beneath it we have the ex- and supra-occipitals (*so*), with the occipital condyle (*c*).

If the skull be viewed from behind, we see extending beyond it globular mass (the upper walls of which are formed by the parietals (Fig. 47, *p*)) the zygoma, widely arching out on each side (*z*) the much smaller post-orbital processes of the frontal (*pf*) above and the depending, rounded, auditory bullæ (*b*) below. In the middle, between the bullæ, there is the foramen magnum (*fm*) with the occipital condyle (*oc*) on each side of it. The bulla is seen to be clamped laterally and behind by the mastoid (*ms*) and par-occipital processes, which are closely applied to it. The foramen magnum is bounded above by the supra-occipital (*so*), on each side of which the lambdoidal ridge (*l*) runs up to the interparietal (*ip*).

In the lower jaw we see the angle (*a*), the great transverse extent of the articular condyle (*f*), and the lofty coronoid process (*c*).

If the skull be examined *dorsally*, the two large frontals and parietals will be seen separated by the crucial mark formed by the sagittal, frontal, and coronal sutures, while the maxillæ, premaxillæ, and nasals, are conspicuous in front (Fig. 28). The floor of the orbit is also well seen to be composed mainly of the maxilla (*m*), with the help of palatine (*p*) and lachrymal (*l*) internally, and of the malar (*j*) externally. The posterior opening of the infra-orbital canal also comes into view as well as the posterior palatine foramen (4) and the spheno-palatine foramen (5). The inward curvatures of the post-orbital processes of the malars (*j*) and the outward curvatures of the frontal post-orbital processes (*pf*) are also very marked from this point of view.

In the INSIDE OF THE CRANIUM, as seen from above when a horizontal section is made and the top of the skull is removed, we may note the following conditions:—

In the middle, in front, is a small fossa bounded anteriorly by the ibriform plate, and on each side by the orbital plates of the frontal. his is the *olfactory*, or *rhinencephalic*, *fossa*, which shelters the factory lobes of the brain. The hinder part of its floor is formed the pre-sphenoid.

Behind the olfactory fossa is the great *middle fossa* of the cranium, unded posteriorly by the ossified tentorium, which is attached to e parietals and petrosals. In the middle of the floor of this great amber is the pituitary fossa, or sella turcica (Fig. 49), situated on e upper surface of the basi-sphenoid. On each side of this (placed cessively in series running backwards and outwards) are (1) the tic foramen (piercing the orbito-sphenoid); (2) the sphenoidal sure (placed beside the anterior wall of the pituitary fossa);) the foramen rotundum; and lastly (4) the oval foramen; the tter being on a line with the hinder part of the pituitary fossa.

External to this line of foramina on each side, there is a depression n the upper surface of the ali-sphenoid and squamosal) which is lled the internal temporal fossa, because it shelters the temporal be of the brain.

Behind the pituitary fossa is the clinoid plate, and behind and ternal to this on each side is an opening between the petrosal, e ali-sphenoid, and the anterior end of the tentorium, which pening communicates with the cavity of the auditory bulla and with e *foramen lacerum anterius*.

Behind the clinoid plate and the tentorium, is the *posterior fossa* of e cranium—called also the *cerebellar fossa*, because it shelters that art of the brain called the cerebellum. The floor of this fossa is formed y the basi-occipital, and its sides by the ex-occipitals and petrosals.

Between the basi-occipital and the adjacent petrosal there runs rwards on each side a very minute canal destined for the carotid rtery. The surface of the petrosal exhibits the conspicuous pening to the internal ear—the meatus auditorius internus—with e fossa above it for a process of the cerebellum (Fig. 35, B, *cb*), bove and behind which again is the prominence indicating the nterior vertical semi-circular canal.

Behind each foramen lacerum posterius, and separated from it y a narrow bridge of bone, is the anterior condyloid foramen. The ner surface of the sides and roof of the cranium is marked by wide nd shallow depressions corresponding with eminences on the surface f the brain, and also with narrow meandering grooves indicating the urse of the blood-vessels.

The skull VERTICALLY BISECTED, *in the direction of the sagittal ture*, exposes the larger size of the brain cavity than of the part hich forms the face; also the inclined condition of the cribriform ate (Fig. 48, *cp*) and the more nearly vertical position of the foramen agnum at quite the hinder end of the skull.

The basilar parts of the occipital and sphenoid bones (Fig. 49, *bo*, *bs*, d *ps*,) are seen to become thicker as we go forwards; they form the e axis of the skull, and a line drawn from the anterior margin of

the foramen magnum to the front end of the middle part of the

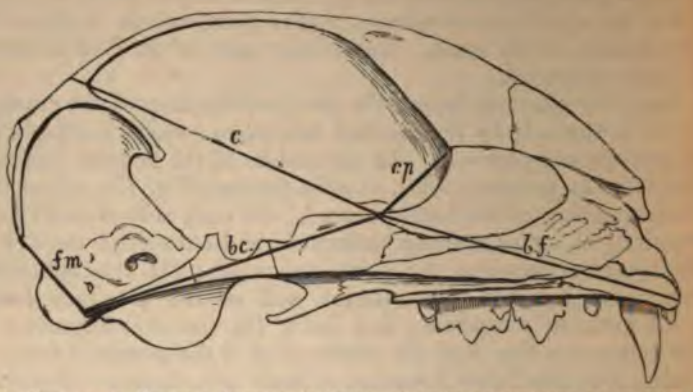


Fig. 48.—Outline of Vertical Section of Skull, to show by straight black lines the inclination of the Basi-facial Axis to the Basi-cranial Axis, and the angle formed with the latter by the planes of the Cribriform Plate and Occipital Foramen; also the relative Cerebral Length.

bc. Basi-cranial axis.
bf. Basi-facial axis.
c. Length from the front end of the basi-cranial axis to the summit of the attachment of the tentorium.
cp. Plane of cribriform plate.
fm. Plane of foramen magnum.

upper (or cerebral) surface of the pre-sphenoid is called the *basi-cranial axis* (Fig. 48, *bc*). A line drawn from the same point of the

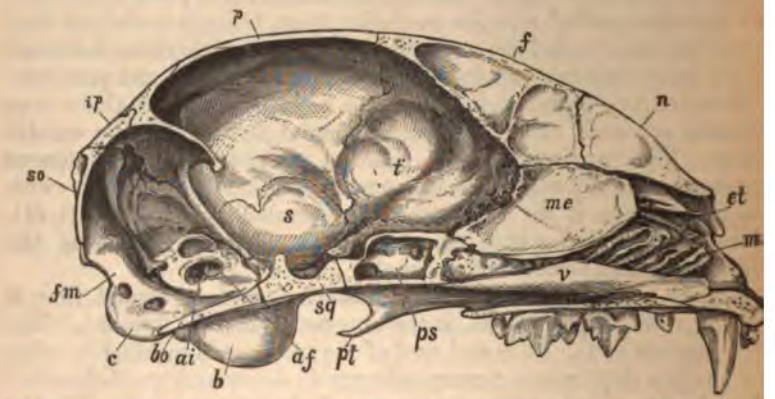


Fig. 49.—Vertical Antero-posterior Section of Skull, made a little nearer the Spectator than the exact middle line to show the Median Ethmoid, etc.

af. Aqueduct of Fallopius.
ai. Internal auditory meatus.
b. Auditory bulla.
bo. Basi-occipital.
c. Occipital condyle.
et. Lateral ethmoid.
f. Frontal.
fm. Foramen magnum.
ip. Inter-parietal.
me. Mesethmoid.
mt. Ethmo-turbinal.
n. Nasal.
ps. Pre-sphenoid.
pt. Pterygoid.
s. Squamosal.
sq. Basi-sphenoid.
so. Supra-occipital.
t. Inner surface of frontal.
v. Vomer.
The anterior condyloid foramen above and *bo*, just over the letter *b*.

pre-sphenoid to the front part of the alveolar margin of the pre

maxilla is the *basi-facial axis* (*bf*), and the two axes in the cat form an angle of 145°.

The basi-cranial axis forms with the foramen magnum (*fm*) an angle of 110°, while with the cribriform plate (*cp*) it forms one of 155°—open upwards and backwards.

The extreme length of the line (*c*), slightly exceeds that of the basi-cranial axis (*bc*), while it is itself somewhat exceeded by the *cerebral length, i.e.*, the length between the front end of the olfactory fossa and the hind-most point of attachment of the tentorium.

As to the details of the parts shown in a median vertical section, we see in the first place the large cerebral chamber (Fig. 49, *s, t*), in front of which is the more solid, facial part with the mesethmoid (*me*) interposed between the vomer (*v*) below and the inflected plates of the frontal and the nasal (*f, n*).

The cerebral chamber is seen to be bounded behind by the bony tentorium descending as a free process from the hinder end of the parietal (*p*), and being attached to the inner anterior margin of the petrosal. In the petrosal we see the internal auditory opening (*ai*) in a fossa, from the anterior part of which (*af*) proceeds the aqueduct of Fallopius. Above and slightly behind this fossa, is seen that for the cerebellar process. We see also the concavity of the pituitary fossa in the upper surface of the basi-sphenoid (*sq*), with the large air-cavity in the pre-sphenoid (*ps*). In the ex-occipital we see the anterior condyloid foramen (for transmitting the hypoglossal nerve), with another foramen, for a vein, behind it.

When the skull is cut vertically a little on one side of the antero-posterior median line we then see (Fig. 50) the frontal sinus (*fs*) extending backwards over the anterior part of the cranial cavity. We also see how the ethmo-turbinal, or lateral ethmoid, sends its lamellæ quite upwards in front of the frontal sinus (the upper *et*), as well as horizontally forwards (the lower *et* of Fig. 50). We also see more plainly (than in the perfectly median vertical section) the contrast which exists between the direction followed by the folds and furrows of the ethmo-turbinal and that which the folds and furrows of the maxillo-turbinal (*mt*) follow.

When the skull is divided vertically through the external auditory meati (*i.e.*, transversely, or in the direction of the coronal suture) we see that the basilar part of the occipital forms as it were a centre.

The anterior part of such a section shows the great cranial arch rising above this centre and closed in front, while below it, is the arch of the lower jaw and further forward the arch of the upper jaw—enclosing the double tube of the nostrils, which extends from the anterior to the posterior nares.

The posterior part of the section shows us the hinder part of the great cranial arch rising above around the foramen magnum behind, while below it, is the arch of the hyoid extending downwards on each side from the tympano-hyals to the basi-hyal.

As to the CAVITIES OF THE SKULL: the two orbits are separated one from another in part by the cranial cavity (behind the cribri-

form plate), and in part by the nasal cavity (in front of the cribriform plate).

The *nasal fossæ* extend backwards, above the palate, from the anterior to the posterior nares, and are enclosed between the pre-maxillæ, maxillæ, and palatines, being separated from each other by the median ethmoid and vomer, and, in front of these, by a median cartilage of the nose called "septal." The lateral ethmoid projects forwards into each fossa from the cribriform plate (*cp*).

The roof of the nasal cavity slopes downwards both anteriorly

Fig. 50.—Longitudinal Vertical Section of Face made a little further off than the middle line.

cp. Cribriform plate.
et. Lateral ethmoid or ethmo-turbinal.
fs. Frontal sinus.
mt. Maxillo-turbinal.
m. Maxilla.
p. Palatine.
pm. Pre-maxilla.
ps. Pre-sphenoid.
pt. Pterygoid.

and posteriorly. Its floor is formed by the palatal plates of the maxillæ and palatines, and is pierced, towards its anterior end, by the anterior palatine foramina.

The spheno-palatine foramen opens into the nasal cavity on each side towards the hinder end very near its floor.

The bones of the cranial vault are densest at the surface, beneath which is a coarser, spongy bone-tissue termed "*diploe*." Here and there are much larger cavities, which are filled with air, and are termed *sinuses*. Of such there are two sets.

The first of these, the *frontal sinuses*, are in the substance of the frontals (*fs*), and they communicate with the nasal fossæ. The other set, the *sphenoidal sinuses*, are situated in the pre-sphenoid, and are smaller than the frontal sinuses (Fig. 49, *ps*).

§ **40.** Besides the LIGAMENTS of the skull already noticed—those connecting it with the vertebral column—other ligaments connect the mandible with the cranium.

These may be described as the "capsular" and "stylo-maxillary" ligaments.

The apposed surfaces of the mandibular condyle and glenoid cavity are, in the fresh condition, each coated with cartilage, and

two fibro-cartilaginous disks (inter-articular fibro-cartilages) are interposed between the two articular surfaces. Motion is facilitated by three separate synovial membranes; one between the disks, one between the upper disk and the glenoid surface, and the third between the lower disk and the condyloid surface.

The *capsular ligament* is a fibrous membrane which surrounds the articulation just mentioned, its fibres passing from the circumference of the glenoid surface to the condyle. It adheres to the margins of the interposed fibro-cartilaginous disks, and it is strengthened on its inner and outer sides by certain accessory fibres which might be distinguished respectively as *internal* and *external* lateral ligaments.

The *stylo-maxillary ligament* arises mainly from behind, but partly from in front of the margin of the meatus auditorius externus. It passes to the angle of the mandible.

It gives attachment, on its inner side, to some of the fibres of the internal pterygoid muscle. The stylo-glossus is attached to its upper surface, while its exterior is connected with the masseter.

A thin interarticular cartilage is interposed between the anterior margins of the two horizontal rami of the mandible.

Another cranial ligament which it may be well to mention, is the *post-orbital* ligament which connects the apex of the post-orbital process of the malar with the apex of the adjacent post-orbital process of the frontal.

§ 41. Having now completed our survey of the parts which make up the cranial division of the cat's axial endo-skeleton, the most generalized view of them at present attainable may, perhaps, be expressed as follows:—

The skull consists of a central axis, made up of the basi-occipital, basi-sphenoid, and pre-sphenoid, and which axis is continued on forwards by the median ethmoid.

To this central axis ascending and descending arches are annexed, having certain other structures intercalated between the former. Thus we have an occipital arch completed by the basi-occipital, ex-occipitals, and supra-occipital.

Secondly, we have a posterior sphenoidal arch, completed by the ali-sphenoids and parietals.

Thirdly, we have an anterior sphenoidal arch, completed by the orbito-sphenoids and the frontals. These three arches embrace the brain, which is the enlarged anterior continuation of the spinal marrow and forms the anterior termination of the nervous centres. On this account these arches may be termed "neural," like the vertebral arches which similarly enclose the spinal marrow.

The most anterior, or anterior sphenoidal arch, is open in front, the bone of the olfactory organ (the ethmoid) being, as it were, thrust into the aperture which is left by it.

Into the gap left on each side between the ex-occipital and the ali-sphenoid, the auditory organ (the temporal bone) is thrust.

Similarly, the very much smaller gap left between the ali- and

orbito-sphenoids (which is indeed only represented by a large foram and the sphenoidal fissure) is filled up by the organ of sight, whi though not ossified in the cat (as the olfactory and auditory orga are), is protected by bony processes about it.

Beneath the basis cranii we have:—(1) the thyro-hyals, whi send up no connecting ligaments to the skull, but which throu the basi-hyal are connected, by the epi- and cerato-stylo-hyals wi the tympano-hyals. (2). In front of this hyoidean arch we ha the mandibular arch, and (3) again in front of this we have arch formed by the pterygoid and palatines, and bordered external by the maxillæ and pre-maxillæ. This last arch is amalgamat with the bony covering of the nostrils (the nasals) and with t outer protection of the orbits (the malars), which latter send bac on each side, a bony arch (the zygoma) to the ossified envelope the auditory organ.

Thus we seem to find in the cranial part of the axial skeleton, sort of reminiscence of the structure of the parts composing its spin portion.

From median axial structures which seem to repeat the vertebr centra, neural arches arise and ventral girdles descend, which arch and girdles seem to repeat, on a different scale, the neural and r arches of the trunk.

CHAPTER IV.

THE SKELETON OF THE LIMBS.

1. THE skeleton of the limbs, or appendicular skeleton, is divisible into the skeleton of the anterior, thoracic or pectoral limbs, and that of the posterior abdominal or pelvic limbs.

THE SKELETON OF THE PECTORAL LIMB.

The bones of the cat's PECTORAL LIMB belong to three categories: A. those of the shoulder; B. those of the fore-leg; and C. those of the paw.

A. Those of the shoulder are the blade-bone, called the *scapula*, and the collar-bone, called the *clavicle*. These, with their fellows of the opposite side, constitute what is called the *shoulder-girdle*.

B. Those of the fore-leg are subdivisible into (*a*) the bone of the part above the elbow, called the *humerus*, and (*b*) the bones of the part below the elbow, called respectively the *radius* and the *ulna*.

C. Those of the paw are divisible into three sets: (*a*) the bones of the wrist, called in anatomy the *carpus*; (*b*) those of the middle solid part of the paw, called the *metacarpus*; and (*c*) those of the toes (or digits), which are called *phalanges*.

§ 2. The SCAPULA is a flat, somewhat triangular bone, with three borders and two surfaces. One border is anterior, one is superior, and one is posterior. The superior border (Fig. 51, *v*) is also called "*vertebral*," because it is the one nearest to the vertebral column. The posterior border (*x*) is also called "*axillary*," because it is adjacent to the axilla, or arm-pit. Of its surfaces, one is applied against the ribs, and is concave; it is called the subscapular fossa, and affords attachment to the subscapularis muscle. It presents one or two oblique ridges.

The other (dorsal or outer) surface is divided obliquely into two unequal parts by a prominent ridge, called the *spine* (*s*), on which account the smaller part in front of the ridge is termed the *supra-spinous fossa* (*ss*), and the part behind it (*is*) the *infra-spinous fossa*. These spaces are occupied by correspondingly named muscles.

The spine of the scapula becomes gradually more prominent from the vertebral border of the bone, while at its outer end the spine

projects freely as a small process terminating in a rounded end, and called the *acromion* (*a*); but before so terminating, it gives off a backwardly directed lamellar freely projecting process termed the *metacromion* (*m*).

The anterior border of the scapula (which is rounded and convex) exhibits at its lower end a rounded notch (*n*). Below this notch there rises a short strongly projecting, much curved, pointed prominence, called the *coracoid* process (Fig. 52, *c*).

The superior border of the scapula (*v*) is the shortest. It is very slightly convex.

The *axillary* border is the longest, and is more or less grooved on its inner aspect (*x*). It descends obliquely from the lower end of

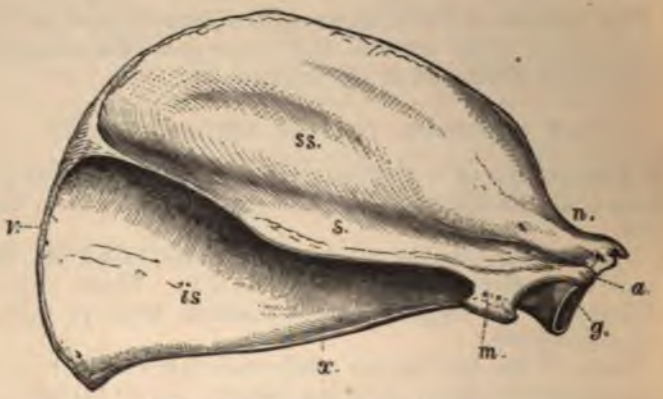


Fig. 51.—RIGHT SCAPULA, SEEN EXTERNALLY.

a. Acromion.
g. Glenoid surface.
is. Infra-spinous fossa.
m. Metacromion.
n. Supra-scapular notch.
s. Spine.
ss. Supra-spinous fossa.
v. Vertebral border.
x. Axillary border.
The coracoid process is shown at the right-hand extremity of the figure above, and to the left of the letter *a*.

the vertebral border to a rounded concave, shallow, articular surface (*g*), called the *glenoid cavity* (into which the head of the upper-arm bone is received), and which is overhung in front by the coracoid process (*c*), while the acromion projects externally to it. The part which supports the glenoid surface is called the *neck*.

The anterior and vertebral borders meet in a rounded prominence, while at the junction of the axillary and vertebral borders is a small flattened space for the insertion of a muscle called the teres major.

The coracoid and acromion arise from distinct centres of ossification. The coracoid ossification contributes to form the glenoid cavity.

The CLAVICLE is a very small slender styliform bone, pointed at each end, and suspended in the flesh between the acromion process of the scapula and the manubrium of the sternum, but not touching either of those parts itself.

§ 3. The HUMERUS is the largest, but not the longest, bone of the

pectoral limb, and extends from the shoulder to the elbow-joint. It is imperfectly cylindrical, being flattened from side to side above, and from before backwards below. It describes a very slight sigmoid curve from above downwards, convex forwards above and concave below.

The cylindrical part (or shaft) has its inner surface marked above by a wide longitudinal depression, termed the *bicipital* groove,

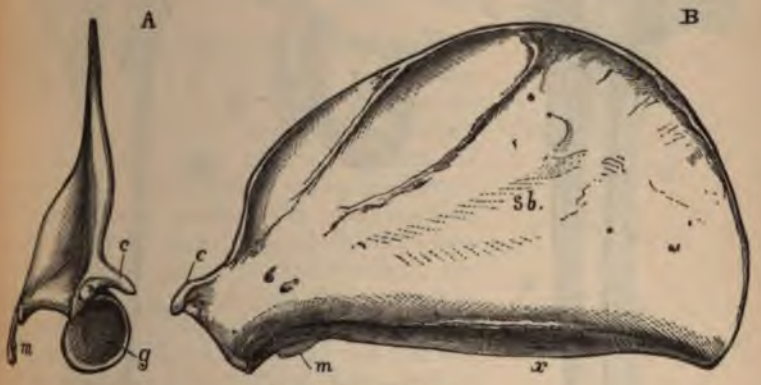


Fig. 52.—RIGHT SCAPULA.

A. Seen from below.
B. Seen from within.
c. Coracoid process.
g. Glenoid surface.
m. Metacromion process.
sb. Sub-scapular fossa (with two oblique ridges)
x. Axillary border, showing its longitudinal groove.
The acromion process is seen in figure A, just above the letter m.

because it lodges the tendon of a muscle called the Biceps. External to this is a slightly roughened and elevated tract (*dr*) called the *deltoid ridge*, as it serves for the insertion of the deltoid muscle.

The lower part of the shaft has its anterior surface separated from the posterior surface by two lines (or ridges), one on each side, which become especially well marked as they approach the lower end of the bone. The outer (*rs*) of these two ridges (which is the stronger and more posteriorly situated of the two) is termed the *supinator*, or *external condyloid ridge*, while the inner one is named the *internal condyloid*, or *pronator ridge*. Just within it is an elongated opening, or foramen, called the *supracondylar foramen* (*fc*), which transmits the median nerve and brachial artery.

On the hinder surface of the shaft (which is generally convex) there may be detected a very slightly marked oblique groove (called the *musculo-spiral*), passing from above downwards and outwards.

The upper end of the humerus shows a large rounded convex head (*h*), covered, when fresh, with cartilage, and articulated to the glenoid surface of the scapula. This head is not placed on the middle of the summit of the bone, but on its hinder and inner aspect, so that its axis does not coincide with that of the shaft.

On the outer and inner sides of the head of the humerus, are two

blunt prominences. One of these (Fig. 54, t^1) and (Fig. 53, ^{1}
termed the *greater* (radial* or preaxial) *tuberosity*, is on the ou
side of the summit of the bicipital groove. It reaches consideral
above the summit of the head of the humerus. At its hinder end

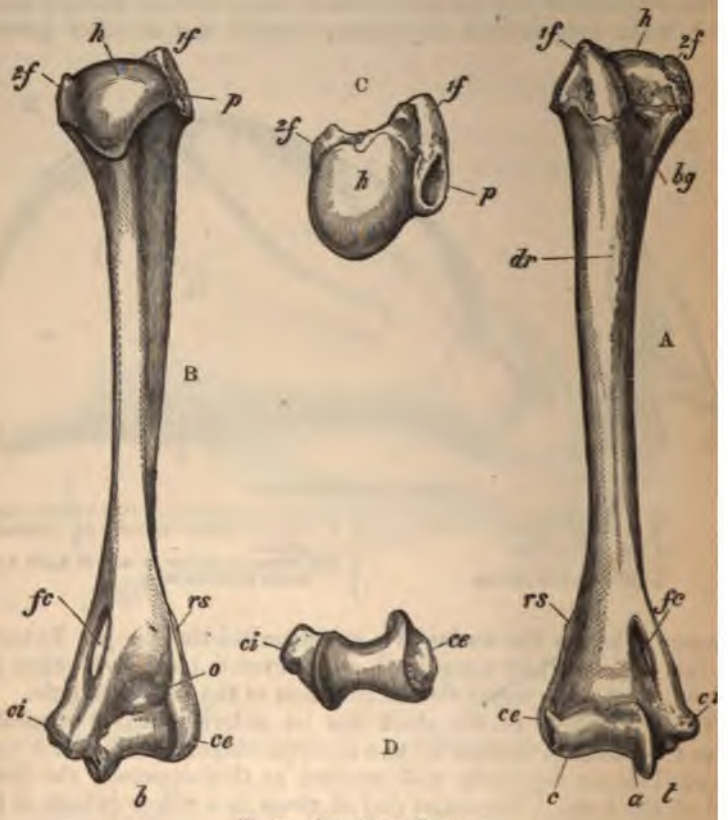


Fig. 53.—THE RIGHT HUMERUS.

A. Front.
B. Back.
C. Summit.
D. Lower end, with its hinder margin at the upper border of the figures.
a. Trochlea.
bg. Bicipital groove.
c. Capitellum.
ce. External condyle.
ci. Internal condyle.
dr. Deltoid ridge.
fc. Supra-condyloid foramen.
h. Head.
o. Olecranal fossa.
p. Surface for infra-spinatus.
rs. Supinator ridge.
t. Inner margin of trochlea.
^1f. Great tuberosity.
^2f. Lesser tuberosity.

a conspicuous depressed surface (*p*), for the insertion of the *in*
spinatus muscle. The other smaller prominence is called the *le*
(ulnar, or *post-axial*), *tuberosity* (Fig. 54, t^2) and (Fig. 53, ^2f),

* "Radial" because on the side of the radius, "pre-axial" because when the arm is vertical, it is in front of the long of the arm.

is placed on the inner side of the bicipital groove. Both tuberosities serve for muscular attachments.

The lower end of the humerus expands considerably, having a lateral prominence termed a condyle, on each side, but the internal condyle (*ci*) projects further inwards than does the external condyle (*ce*) outwards.

Between these projections is placed the lower articular surface for the bones of the forearm.

This is irregularly concave and convex. At its outer part is a rounded prominence (convex transversely as well as from before backwards) called the *capitellum* (*c*), which joins the outer bone of the fore-arm or radius. Internal to this is a pulley-like transversely concave surface (*a*), the *trochlea*, which joins the inner bone of the fore-arm or ulna. The groove of this "pulley" extends completely round from the anterior to the posterior surface of the humerus. The capitellum and the trochlea run one into the other without any distinct demarcation. There is a shallow cavity in front of the humerus immediately above the trochlea. This is called the *coronoid fossa*, because it receives the coronoid process of the ulna. There is another much deeper fossa (*o*), also above the trochlea, but on the hinder surface of the humerus. This is called the *olecranal* or *anconeal fossa*, from the part of the ulna which it receives when the fore-leg is straightened. The inner margin of the distal articular surface of the humerus (*t*), descends much below its external margin.

Fig. 54.—THE INNER ASPECT OF THE HUMERUS.

c. Capitellum.
cf. Supra-condyloid foramen.
ic. Internal condyle.
dr. Deltoid ridge.
h. Head.
t. Inner margin of trochlea.
*t*1. Great tuberosity.
*t*2. Lesser tuberosity.

§ 4. The RADIUS (which is slightly shorter than the humerus) is also a long cylindrical bone, expanded more or less at each end, and flattened on that side which is behind when the fore-leg is so placed that the paw rests on the ground. At its place of attachment above, it is the external bone of the fore-arm. The long middle part of the bone, or shaft, is a little curved, with the convexity forwards and outwards. At the upper part of its inner margin is a prominence called the *tuberosity* (*t*), into which is inserted the tendon of the biceps muscle. Just above this bicipital tuberosity the bone is narrowed into what is called the *neck*, from which rises the *head* (*h*) of the bone. This head is oval in shape, with a smooth margin,

and concave above for articulation with the capitellum humerus.

At its lower end the radius becomes much broadened out, anterior or extensor* surface is grooved for the passage of t

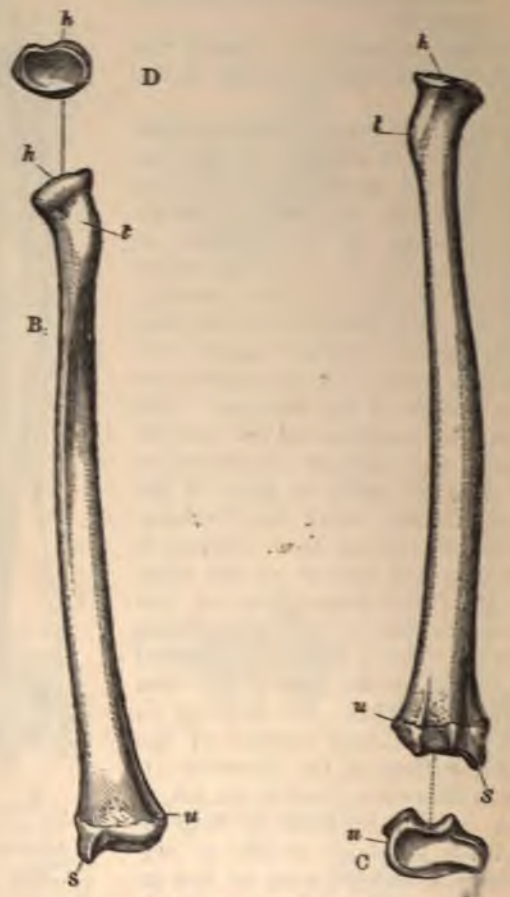


Fig. 53.—The Right Radius.

A. Anterior and outer aspect.
B. Posterior and inner aspect.
C. Distal articular surface for wrist.
D. Proximal surface for humerus.

h. Head.
s. Styloid process.
t. Tuberosity.
u. Surface for ulna.

Its outer side is prolonged into what is called the *process* (*s*). The lower end of the bone articulates with t by a large concave surface supporting the fore-paw, which is

* Called "extensor" because the muscles which stretch the toes are to this surface.

und by and with the radius in that motion of the arm and hand hich is called *pronation* and *supination*—movements which will be xplained when the articulations and ligaments of the pectoral limb

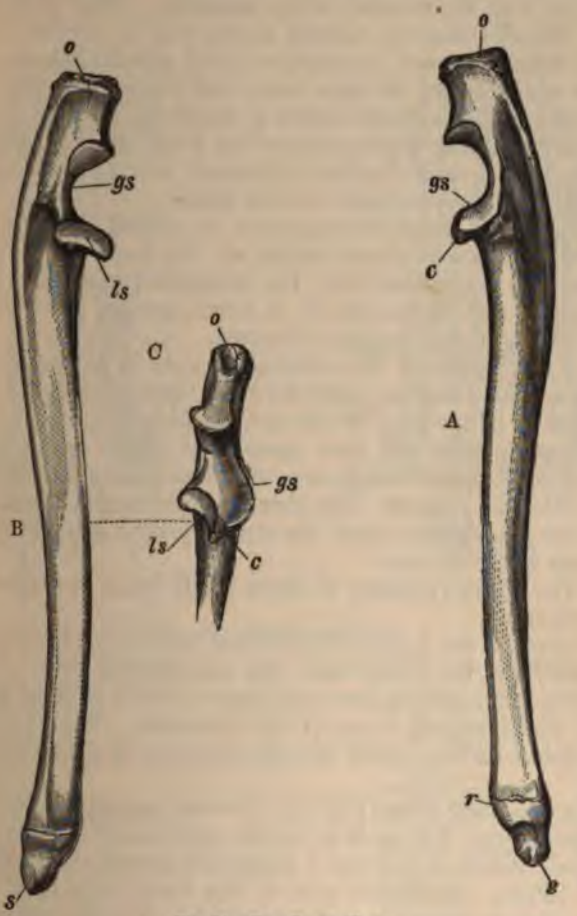


Fig. 56.—The Right Ulna.

A. External aspect.
B. Internal aspect.
C. Surface of sigmoid fossa.
c. Coronoid process.
gs. Greater sigmoid cavity.
ls. Lesser sigmoid cavity.
o. Olecranon.
r. Surface for radius.
s. Styloid process.

e described. The outer lower end of the radius also presents, in- nally, a small articular surface for the ulna (*u*).

5. The ULNA, or post-axial bone of the forearm, is longer than humerus, and considerably longer than the radius. While the er bone is broader below than above, the reverse condition obtains he ulna. The shaft is flattened both in front and behind, with a

rather sharp inner or radial margin, to which a membrane (the interosseous membrane) is attached, which connects the shaft of the ulna with that of the radius.

The upper end of the ulna presents a deep concavity (*gs*) for articulation with the trochlea of the humerus. This fossa is called from its shape, the *great sigmoid cavity*, and is divided unequally by an ill-defined vertical prominence which extends between the two processes which bound the fossa above and below respectively.

The lower of these two processes is called the *coronoid* process (*c*), and is received into the corresponding fossa on the front of the humerus. The inferior surface of its apex is rough, and serves for the insertion of the brachialis anticus muscle.

The higher and much larger process is termed the *olecranon* (*o*), and passes into the olecranal cavity on the back of the humerus when the limb is stretched out. The olecranon forms the prominence of the elbow, and terminates in a rough process or "tuberosity," into which the triceps muscle is inserted.

On the outer side of the coronoid process is a small, elongated concave, articular surface called the *lesser sigmoid cavity* (*ls*), destined for the border of the head of the radius which turns upon it.

The lower end of the ulna presents a small, rounded, convex surface or *head*, which articulates with the adjacent surface of the radius. On the opposite side there is developed a large, laterally compressed prominence called the *styloid process* (*s*), which directly articulates with the wrist.

§ 6. The CARPUS consists of seven small bones arranged in two transverse series.

The bones of the upper or proximal row are: (1) The *scapho-lunar bone*; (2) the *cuneiforme*; (3) and the *pisiforme*.

The first two together form an upper convex surface which fits into the distal articular cup of the fore-arm. The carpus has a convex dorsal surface, while its palmar surface is concave from side to side.

The *scapho-lunar* bone (Fig. 57, *sl*) is the largest of all. Its long axis is transverse. Above, it is smooth and mainly convex, and joins the radius. Below, it fits into a depression formed by the four distal carpals. From the hinder part of the outer side of the bone a tubercle projects outwards and backwards. To this tubercle there may be attached a small bone which is found within the tendon of a muscle here inserted. Such a bone is called a "sesamoid bone."

The *cuneiforme* (*c*) is somewhat wedge-shaped, and articulates below with the innermost, or most ulnar, carpal only.

The *pisiforme* (*p*) is a bone which projects freely backwards and downwards from the palmar surface, having a long, compressed and curved process, which ossifies separately as an epiphysis (see Fig. 60, *pe*). It is mainly supported by the cuneiform, but also articulates with the unciform.

The bones of the distal row are: (1) the *trapezium*; (2) the *trapezoides*; (3) the *os magnum*; and (4) the *unciforme*.

The *trapezium* (*tm*) is the smallest carpal and the most radial of the distal series. It supports the pollex or most radial digit, for which it presents a saddle-shaped articular surface, namely, one both

BONES OF RIGHT FORE-PAW.

Fig 57.—PALMAR SURFACE.

s (Above) scapho-lunar bone.
s (Below) sesamoid.
tm. Trapezium.
u. Unciform bone.
c. Cuneiform bone.
m. Magnum.
mc. Metacarpals
p. Pisiform.
p^1. Proximal phalanx.
p^2. Middle phalanx.
p^3. Distal phalanx.
I. Pollex.
II. Index
III Medius.
IV Annulus.
V. Minimus

Fig. 58.—DORSAL SURFACE.

sl. Scapho-lunare.
ld. Trapezoides.
tm. Trapezium.
u. Unciform bone.
c. Cuneiform bone.
m. Magnum.
mc. Metacarpals.
p. Pisiform.
p^1. Proximal phalanx.
p^2. Middle phalanx.
p^3. Distal phalanx.
I. Pollex.
II. Index.
III. Medius.
IV. Annulus.
V. Minimus.

concave and convex. It is convex from without inwards and convex from before backwards.

The *trapezoides* (*td*) is also a small carpal. It articulates distally by a slight convexity, with the second metacarpal bone only. It is very little visible on the palmar surface.

The *os magnum* (*m*) is considerably larger than the two preceding carpals. It is convex above at its so-called "*head*." It articulates below with three metacarpals, but mainly with the third, into the proximal concavity of which it projects.

The *unciform* bone (*u*) is that carpal which lies on the ulnar side of

the distal row. It articulates slightly with the fourth, but mainly with the fifth metatarsal. Its upper surface is narrow and convex. Its palmar surface developes a small process which is called the "palmar process."

Fig. 59.—Bones of Medius Digit.

m. Magnum.
mc. Metacarpal.
s. Scaphoid.
p^1. Proximal phalanx.
p^2. Median phalanx.
p^3. Distal phalanx.
a. Its apex embraced by claw.
b. Sheath of bone enclosing root of claw externally.

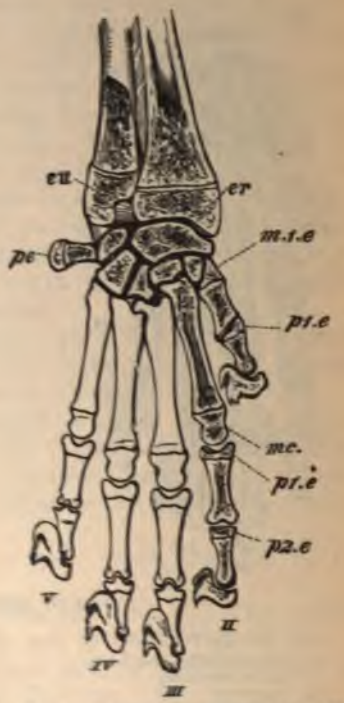


Fig. 60.—Vertical Section through Bones of Arm, Wrist, Pollex, and Index, to show Epiphyses.

mle. The epiphysis of the metacarpal of the pollex
mc. That of the index.
p^1e. That of proximal phalanx of pollex and index
p^2e. That of second phalanx of index.
pe. That of pisiform.
eu. That of radius.
er. That of ulna.
I, II, II, IV, and V. The digits.

§ 7. The METACARPUS consists of four elongated, and one short, matacarpal bones, each supporting a digit (toe) at its distal end.

Each metacarpal has its proximal end, or base, specially moulded so as to fit that part of the surface of the carpus which it adjoins. The distal end of each is in the form of a rounded head.

The metacarpals are curved so as to be slightly concave, from above downwards, on their palmar aspect. The dorsal surface of each is slightly more flattened than is the opposite side.

The first metacarpal (that of the pollex) is less than half the length of the shortest of the others, and differs from them by its ossification, its epiphysis being situate only at its proximal

end, while in each of the other metacarpals there is an epiphysis at the distal end only (Fig. 60).

The proximal surface of the first metacarpal is deeply concave from side to side, and convex from before backwards, to suit the saddle-shaped surface of the trapezium which supports it.

The four other metacarpals decrease in length outwards from the third, and the second is slightly shorter than the fourth, but longer than the fifth.

The articular surfaces of the heads of the metacarpals extend further on the palmar than on the dorsal aspect.

Each on its palmar aspect has a median ridge, on each side of which a small rounded ossicle, called a *sesamoid bone* (*s*), is attached.

The ulnar side of the proximal end of the fifth metacarpal exhibits a slight prominence or tuberosity.

The distal surface of the first metacarpal slopes obliquely downwards and towards the ulnar side.

§ 8. The toes, or DIGITS, of the fore-paw (corresponding to our thumb and four fingers) have each a distinguishing name.

Thus the first digit (thumb) is termed the *pollex*.

The second is the *index*.

The third is the *medius*, or middle digit.

The fourth is the *annulus*, or ring digit.

The fifth is the *minimus*, or little digit.

Each digit consists of three rather elongated bones termed PHALANGES, except the pollex, which has but two.

Each phalanx ossifies by an epiphysis, which is situated at its proximal end (Fig. 60, p^1 *e* and p^2 *e*).

The two phalanges of the pollex are of nearly equal length.

In every other digit the phalanges become successively shorter and smaller, the third phalanx being, however, but little smaller than the preceding one, while it is vertically expanded to support the claw.

The phalanges of the proximal row (p^1) are somewhat curved like the metacarpals. They are smooth and transversely convex dorsally; on the palmar surface they are flat or somewhat concave, each lateral margin being somewhat raised. At their proximal end each is concave (for the supporting metacarpal), but distally each presents two condyles divided by a shallow groove.

The middle row of phalanges (p^2) are like the proximal ones, except that they are smaller, and that each presents at its proximal end a median elevation with a concavity on each side, these concavities joining the convexities of the proximal metacarpals.

The penultimate phalanx of each digit, except the pollex, is hollowed out on its outer (or ulnar) side, and the ultimate phalanx habitually lies bent back, reposing in the cavity thus prepared for it.

Each distal phalanx (Fig. 59) has its proximal end produced backwards below, so that, when the bone is placed with its long axis horizontal, its articular surface looks upwards. Beyond this

the phalanx is very much compressed laterally, ending distally in a sharp, vertically-curved process (*a*) like the upper beak of a bird of prey, and greatly flattened from side to side. A thin lamella of bone projects forwards (*b*) above and on each side of the base of this beak, enclosing a deep groove for the reception of the claw.

Two small round extra bones, called *sesamoid* bones (*s*), are (as before said) placed beneath the junction of the proximal phalanx and metacarpal of each of the digits.

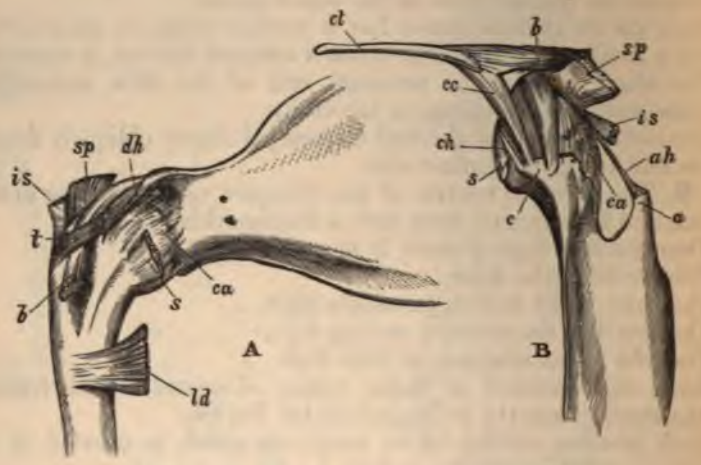


Fig. 61.—Connexions of Right Humerus and Scapula.

A. Seen within.
B. Seen from above.
a. Acromion process.
ah. Fibres from acromion to capsule.
b. Tendon of *biceps*.
c. Coracoid process.
cc. Capsular ligament.
ca. Coraco-clavicular ligament.
ct. Clavicle.
dh and *ch*. Fibres from coracoid to capsule or coraco-humeral ligament.
is. *Infra-spinatus*, cut short.
ld. *Latissimus dorsi*, cut short.
s. *Sub-scapularis*, cut short.
sp. *Supra-spinatus*, cut short.
t. Transverse fibres.

§ 9. The pectoral limb, as a whole, is connected with the dorsal part of the axial skeleton neither by cartilage nor ligament, but by muscular connexion only. It is, however, connected with the ventral part of that skeleton, namely, with the sternum and with the first rib, by ligamentous union. Such a union exists between the sternum and the rudimentary clavicle on the one part, and between the clavicle and the scapula on the other part; for the clavicle is connected with the coracoid process by a ligament called *coraco-clavicular* (Fig. 61, *cc*).

The shoulder-joint is a remarkably free one, allowing the fore-leg to be rotated to a considerable extent in all directions. The cartilaginous cup of the glenoid is deepened by a circular ligament (the *glenoid ligament*) which surrounds its margin.

The joint is surrounded by a *capsular ligament* (*ca*), which extends down from the glenoid ligament round the head of the

humerus, to be inserted into the neck. It is lined by synovial membrane.

An accessory ligament, called the *coraco-humeral* (Fig. 61, *dh*), passes from the coracoid process to the capsule and great tuberosity.

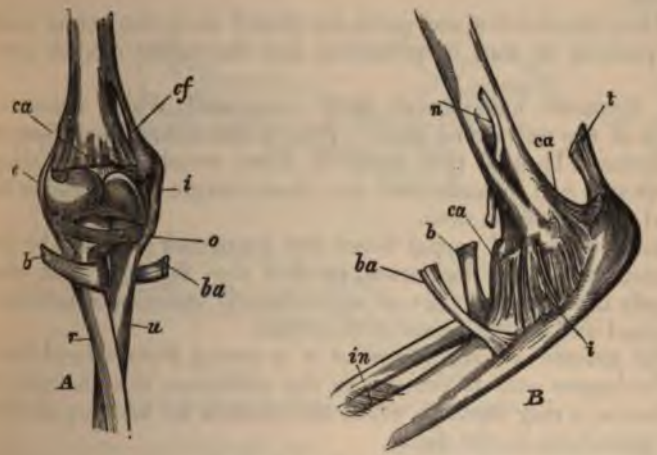


Fig. 62.—RIGHT ELBOW.

A. Seen in front.
B. Inner side.
b. Tendon of biceps.
ba. *Brachialis anticus.*
ca. Posterior ligament.
cf. Condyloid foramen.
e. External lateral ligament.
i. Internal lateral ligament.
in. Inter-osseous ligament.
n. Median nerve.
o. Orbicular ligament.
r. Radius.
t. *Triceps*, cut short.
u Ulna.

The lower end of the humerus so fits into the greater sigmoid cavity of the ulna as to permit the bending of the last-named bone to and fro upon the humerus.

This joint is enclosed in a capsule furnished with a large synovial membrane, and surrounded by four ligaments. (1.) The *internal lateral ligament* (Fig. 62, *i*) radiates from the inner condyle to the coronoid process and inner olecranal margin. (2.) The *external lateral ligament* (*e*), which is much smaller, proceeds from the external condyle to what will be shortly noticed as the annular ligament of the radius. (3.) The *anterior ligament* descends from above the coronoid fossa, while (4) the *posterior ligament* (*ca*) proceeds from the margins of the olecranal fossa to the olecranon.

The upper end of the radius articulates with both the ulna and humerus. Its head joins the lesser sigmoid cavity of the ulna, while from the front and hinder ends of that lesser sigmoid cavity a strong fibrous band proceeds and unites opposite the cavity, thus forming a ring, the *orbicular ligament* (Fig. 60, A, *o*), which embraces the head of the radius. This head rotates upon the capitellum (round the radius's long axis) within the annular ligament.

The radius (with the paw which it carries with it) is thus able to

perform the motions of *pronation* and *supination* without danger o dislocation.

When the fore-leg and paw hang down, the sole of the fore foot—or palmar surface—being directed forwards, the position i that of supination, and the bones of the fore-arm are situate sid by side.

When the fore-leg and paws are placed as in the act of walking the position is that of pronation, and the radius crosses over th ulna.

A ligament has already been mentioned which connects th shafts of the radius and ulna. This is the *interosseous ligament* o *membrane*. It is a thin sheet of fibres which proceed obliquel downwards and inwards from the ulnar margin of the radius to th radial margin of the ulna.

The two rows of carpal bones are connected together by dorsa palmar, and lateral ligaments, so that they form an arch concav towards the palm. Synovial membrane is interposed between th proximal and the distal series of carpals.

The *anterior annular ligament* is a strong fibrous band from th scapho-lunare and trapezium to the pisiforme, thus forming, wit the bones, a ring through which the tendons for bending the finge may pass down to the digits.

The *posterior annular ligament* proceeds from the outer margin o the lower part of the radius to the inner part of the cuneiform an pisiform, forming a sheath through which the tendons for extendin the fingers pass down to the digits.

The proximal ends of the four ulnar metacarpals are joined t the carpus by dorsal, palmar, and interosseous ligaments. The firs metacarpal is united to the trapezium by a capsular ligament Synovial membranes are interposed between the successive phalanges and between the phalanges and the metacarpals. The distal end of the metacarpals are united to the proximal phalanges by latera and palmar ligaments.

The last phalanx of each digit is bound to the last but one by very elastic ligament (Fig. 63), which passes from the dorsal surfac of the hinder part of the distal phalanx to the distal part of th middle phalanx, and by its action keeps the former phalanx rolle back upon the latter. It is put on the stretch, and the claw drawn downwards by a flexor tendon (to be described with th muscles), which is held in place by a ligamentous loop attached t the palmar surface of the proximal phalanx.

An *intermetacarpal ligament* passes from the palmar aspect of th distal end of the metacarpal of the pollex to the distal palma surface of the metacarpal of the index.

§ 10. A GENERAL VIEW of the pectoral appendicular skeleto shows us that it forms an incomplete bony girdle, which is attache to the axial skeleton on its dorsal aspect by soft parts only; but is connected with the ventral parts of the appendicular skelet by the clavicles and by ligaments. The elbow-joint is so bent as

open forwards, and when the body is supported as in walking, the fore-legs are in pronation.

The skeleton of the fore-leg below the elbow is divisible into a tri- and a bi-digital series, placed side by side.

Thus there is, first, the radius; the scapho-lunar bone; the

Fig. 63.—DIGIT OF FORE-PAW, WITH ITS LIGAMENTS.

Showing the elastic ligament which passes from above the root of the claw, downwards and backwards to the distal part of the second phalanx; also the long flexor tendon (which by being pulled backwards draws down the claw) passing through the ligamentous loop attached to the under surface of the middle phalanx. The sesamoid bone beneath the distal end of the metacarpal is also shown.

trapezium, the trapezoides, and the magnum; the first, second, and third metacarpals; and the annexed digits forming the tri-digital series.

We have, secondly, the ulna; the cuneiform; the unciform; the fourth and fifth metacarpals; and the corresponding digits—forming the bi-digital series.

THE SKELETON OF THE PELVIC LIMB.

§ 11. The bones of the cat's PELVIC LIMB are divisible (like those of its pectoral limb) into three categories: A, that of the hip; B, that of the hind-leg; and C, that of the hind-foot.

A. The skeleton of the hip, or haunch bone, is called the *os innominatum;* and there is one such on either side in the adult animal.

B. The skeleton of the leg is sub-divisible into (*a*) that of the thigh, which consists but of one bone, called the *femur;* (*b*) that of the lower part of the leg, which consists of two bones placed side by side. The larger of these is called the *tibia;* the other, much more slender and placed on the outer side of the leg, is called the *fibula.* It is also called the peroneal bone of the leg, because it clasps, as it were, the larger bone.

C. The skeleton of the hind-foot, like that of the fore-foot, is

sub-divisible into three parts. (*a*) that of the ankle, the *tarsus;* (*b*) that of the middle part of the foot, the *metatarsus;* and (*c*) that of the toes, or digits, composed of *phalanges*, like those of the digits of the fore-paw.

§ **12.** The os INNOMINATUM is a large bone, which meets its fellow

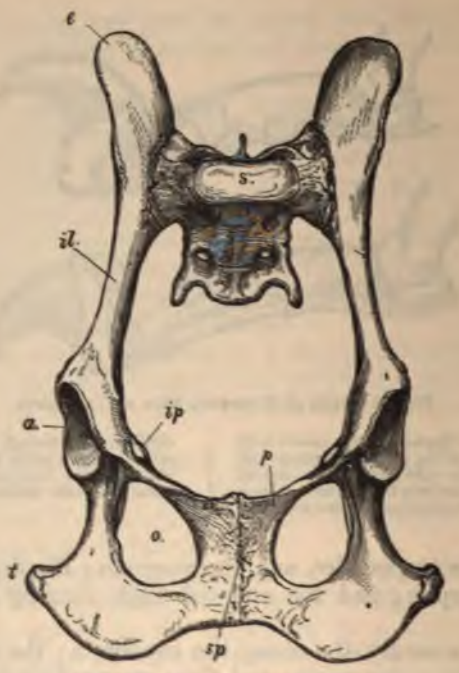


Fig. 64.—THE PELVIS, SEEN IN FRONT.

a. Acetabulum.
Crest of ilium.
il. Ilium.
ip. Ilio-pectineal eminence.
o. Obturator foramen.
p. Pubis.
s. Sacrum.
sp. Symphysis pubis.
t. Tuberosity of ischium

of the other side in the mid-ventral line of the body, and is strongly attached to the sacrum (*s*) above. It thus forms, with the intervention of the last-named bone, a solid bony girdle, called the PELVIS, supporting the trunk above, and being itself imposed on the hind-limbs below. The head of the thigh-bone fits into a socket —the *acetabulum* (*a*)—on the outer side of the os innominatum.

This bone consists of two main parts, one above and in front of, and the other below and behind the acetabulum. The upper portion forms one continuous piece of bone, but the lower part is perforated by a large aperture, termed the *obturator foramen* (*o*). Each os innominatum is made up originally of three distinct bones, which become united when the cat is full-grown. These three bones are the *ilium*, the *ischium*, and the *pubis*.

The innominate bone thus consists of three parts:—

(1). An elongated upper part joins the sacrum and extends down to the socket for the thigh. This is the ILIUM (*il*).

Fig. 65.—RIGHT OS INNOMINATUM, EXTERNAL ASPECT.

Fig. 66.—RIGHT OS INNOMINATUM, INNER ASPECT.

a. Acetabulum.
ar. Auricular surface.
c. Crest of the ilium.
t. Articular surface of pubis.
il. Ilium.
ip. Spine of ischium.
o. Obturator foramen.
p. Tuberosity of ischium.
i. Pubis.
The ilio-pectineal eminence is seen in Fig. A., between *a* and *t*, and in Fig. B., above *t*, on a line with the upper margin of the obturator foramen.

(2). From the thigh-socket a bar of bone runs downwards, inwards, and ultimately backwards. This is the PUBIS (Fig. 64, *p*, and Figs. 65 and 66, *t*).

(3). Another, stouter, piece of bone curves first backwards from the thigh-socket, then downwards and forwards till it meets the pubis. This is the ISCHIUM (Fig. 46, *t*, and Figs. 65 and 66, *p*).

The *ilium* has a slightly concave outer surface, the upper border of which is termed the "*crest*" (*c*), and is somewhat convex and arched. This surface is also called "*gluteal*," because the gluteal muscles are attached to it. From the front end of the crest the *anterior* border descends sharply to the pubis, a blunt prominence (called the *ilio-pectineal* eminence) marking the point of junction. Another prominence (the *anterior spinous process*) projects from the anterior border of the ilium near its summit. From the hinder end of the crest of the ilium descends its posterior border, the summit of which is marked by the *posterior spinous process*, separated by a wide notch from a small marked prominence, called the *spine of the ischium* (*ip*).

The inner surface of the ilium is slightly concave, forming the *iliac fossa* (*il*) and at its anterior and upper part is a rough irregular space, called the *auricular surface* (*ar*), for articulation with the sacrum. The ilium forms about the upper third of the socket for the thigh-bone.

The PUBIS, or pubic bone, forms the inner part of the thigh-socket, joining the ilium above, and at its junction contributing to form the ilio-pectineal eminence. It thence descends inwards (as a band of bone flattened from without inwards, called the horizontal ramus) till it meets with its fellow of the opposite side, when it turns sharply backwards and downwards. The junction of the two pubes is termed the *symphysis* (*sp*), and the part of each pubis next the symphysis is sometimes called the *body;* thence the pubis runs outwards and backwards, as a flattened band, till it meets the ramus of the ischium.

The ISCHIUM forms the outer and hinder part of the thigh-socket, and indeed of the whole os innominatum. The *body* of the ischium forms about two-fifths of the socket for the thigh, which cavity is situated on its anterior and outer side. The body is broad, and sends from its posterior upper margin a slightly marked process, called the *spine* of the ischium (*ip*). Behind this, and behind the socket, the bone contracts somewhat, and then expands again, the expansion having a rough, outwardly projecting prominent surface, which is called the *tuberosity* of the ischium (*p*); and it is the two tuberosities (of the two ossa innominata) which support the body when in the sitting posture (Fig. 64, *t*). Just below the tuberosity, the ischium sends forth a flat band of bone (the ramus), which, curving forwards and downwards, meets the bony band of the pubis spoken of above. Between the spine and the tuberosity of the ischium the posterior upper margin of the bone is slightly concave.

The socket for the thigh-bone (which has been so often referred to) is called the *acetabulum*, or *cotyloid* cavity. It has a prominent rim, except at the inner and lower part where the rim is interrupted

by a notch (the cotyloid notch). There is no perforation in the acetabulum, but its surface just within the notch is depressed, the depression affording attachment to the very strong *ligamentum teres* (or round ligament) which goes from it to the head of the thigh-bone.

Enclosed by the ilium, ischium, and pubis, there is an oval space called the *obturator foramen*, one such being placed on each side of the pubic symphysis (*o*).

The concavity in the posterior border, between the posterior spinous process of the ilium and the spine of the ischium, is called the *greater ischiatic notch*; the other concavity, between the spine of the ischium and the tuberosity of that bone, is called the *lesser ischiatic notch*.

The width from side to side of the pelvis is about equal to its depth from the brim of the pubis to midway between the tuberosities of the ischia. Either of these dimensions is much less than half the greatest extent of the ossa innominata.

§ 13. The FEMUR is a bone of about the same length as the ulna, and, like the humerus, is more or less cylindrical, with a rounded head above (to fit into the acetabulum), and with an expansion below with two articular surfaces.

The shaft, which is nearly straight, is smooth in front, but has an oblique ridge behind, termed the *linea aspera*, which is most marked about half-way up the bone (*la*).

At the upper end of the shaft are two conspicuous projections. The external one of these (projecting from the outer margin of the bone, which it continues upwards), is called the *great*, or *peroneal trochanter* (*gt*). The internal projection, which is much smaller, more conical, and rounded, stands out from the inner and hinder side of the bone, and is called the *lesser*, or *tibial trochanter* (*lt*).

Between the two trochanters, on the hinder side of the femur, a bony prominence extends, which is termed the *posterior inter-trochanteric ridge* (*r*); and a very slightly marked line, the *anterior inter-trochanteric ridge*, also connects the two trochanters on the front surface of the femur.

On the inner and hinder side of the great trochanter is a pit, termed the *trochanteric fossa* (*f*).

From between the inter-trochanteric ridges a narrower portion of bone, compressed antero-posteriorly, projects inwards, forming a slightly obtuse angle with the shaft. This is called the *neck of the femur* (*n*). It ends in a rounded *head* (forming a large part of a sphere) which (*h*) fits into the acetabulum.

On the hinder part of the inner side of the head of the femur there is a very distinctly marked depression, or pit, which serves for the attachment of the ligamentum teres (*p*).

On the outer side of the hinder part of the femur, a little below the great trochanter, is a more or less marked vertical ridge, which serves for the insertion of the gluteus maximus muscle.

At the lower end of the femur are two rounded prominences,

elongated from before backwards, and of nearly equal size, n
condyles, separated behind by a median depression (*ap*).

The *external* condyle (*ec*) has on its outer surface a depressi
the tendon of the *popliteus* muscle. Immediately above this
slight prominence of the external tuberosity, immediately

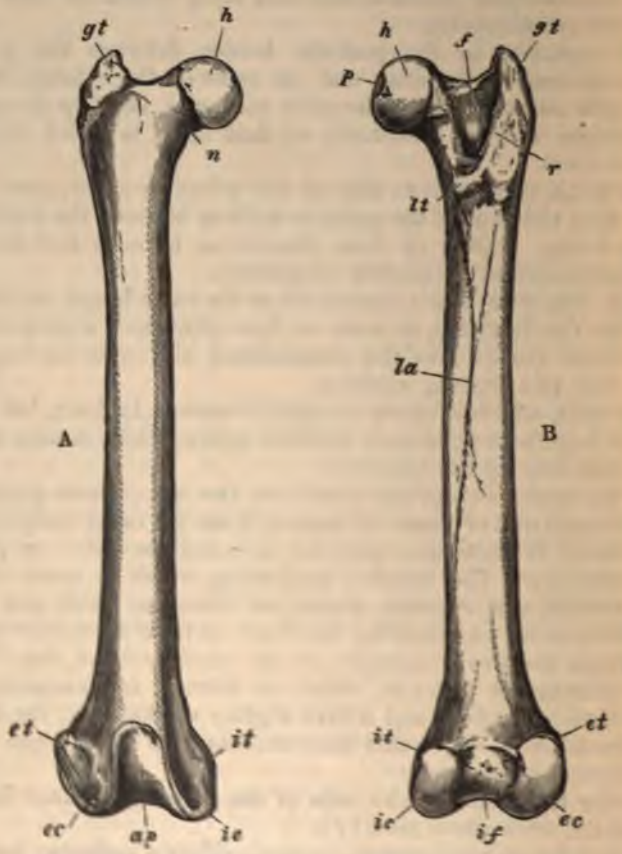


Fig. 67.—The Right Femur.

A. Anterior aspect. B. Posterior aspect.

which is a small, but deeply marked pit for the tendon of the g
cnemius muscle, and the sesamoid to which that tendon is atta

The *internal* condyle is slightly longer, and descends a little
down than the external one. On its inner side is a projection
the *internal tuberosity* (*it*).

The articular surfaces of the condyles meet in front, and for
elongated, transversely concave, ascending articular surface (*a*

e knee-pan. Posteriorly they diverge, leaving between them a pace called the *inter-condyloid fossa* (*if*). The femur does not rticulate with the fibula.

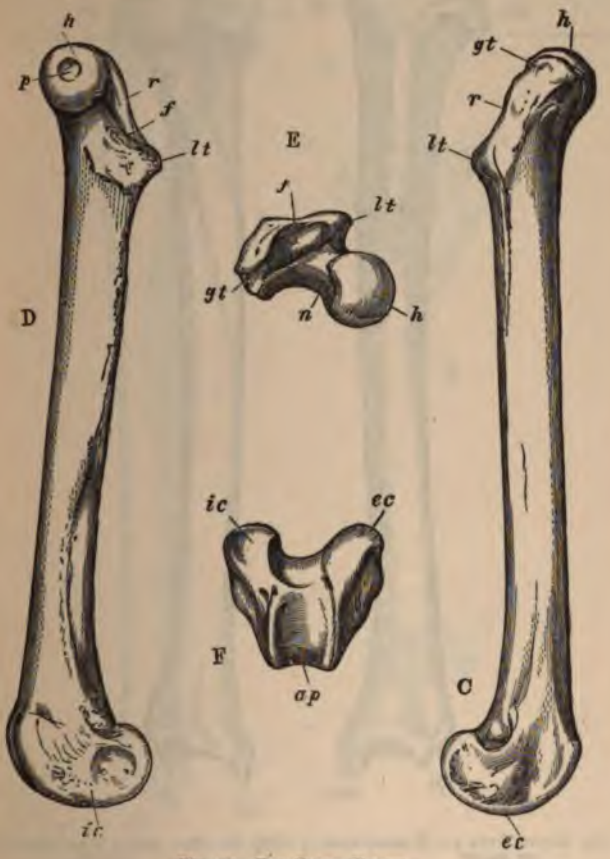


Fig. 68.—The Right Femur.

EXPLANATION OF LETTERS IN FIGS. 67 AND 68.

C. External view.
D. Internal view.
E. Proximal end.
F. Distal end.
ap. Surface for patella.
ec. External condyle.
et. External tuberosity.
f. Trochanteric fossa.
gt. Great trochanter.
h. Head.
ic. Internal condyle.
if. Inter-condyloid fossa.
it. Internal tuberosity.
la. Linea aspera.
lt. Lesser trochanter.
n. Neck.
p. Pit for ligamentum teres.
r. Posterior inter-trochanteric ridge.

In Fig. C, a depression may be observed at the lower end of the shaft posteriorly, just above the external condyle. It is for the sesamoid to which the gastrocnemius muscle is attached. The depression in the hinder part of the external condyle itself, is for the tendon of the popliteus muscle.

§ 14. The knee-pan, or PATELLA, is a small bone of an elongated al shape, which is convex in both directions externally, while ternally it is convex transversely, but concave from above down-

wards, and so fits into the median articular surface at the l
of the front surface of the femur.

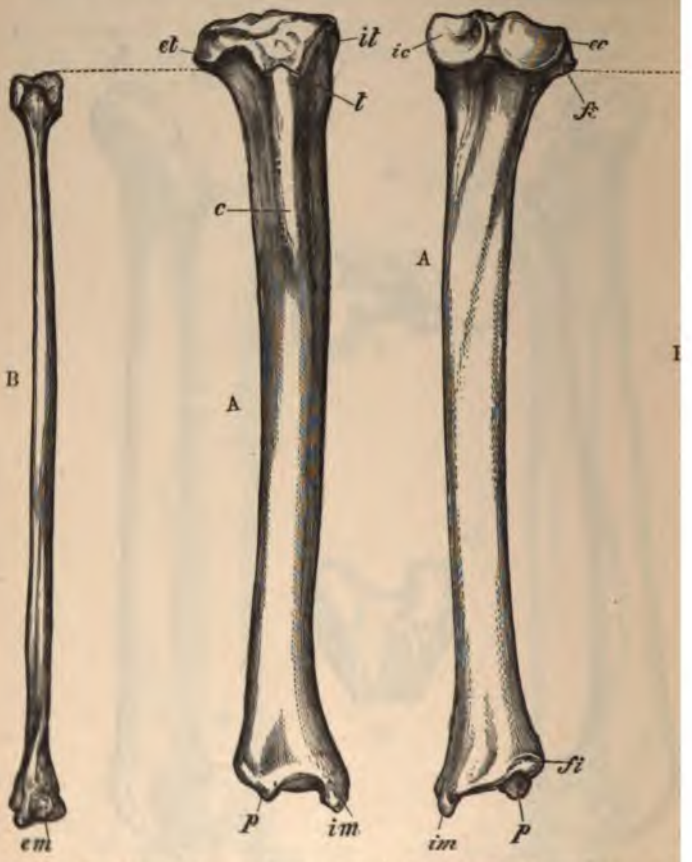


Fig. 69.—The Right Tibia and Fibula, seen in front.

A. Tibia. B. Fibula.

Fig. 70.—The Right Tibia and
behind.

A. The tibia. B. The

It is attached above by its broad upper margin to the t
the front muscle of the thigh. Below, a ligament goes
pointed lower end to the upper part of the shin-bone.

§ **15**. The TIBIA, or shin-bone, is the absolutely longest
the cat's skeleton. It transmits the weight of the hinder
the body from the thigh to the foot.

Its upper end is very wide, and presents two articular
(*condyles*)—which are each convex from before backwa
slightly concave from side to side (*ec* and *ic*), and which re
two condyles of the femur. Between these articular surfa
is a depression, or pit, giving insertion to one end of on
crucial ligaments which connect the femur with the tibia.

On the two sides of the proximal end of the tibia are two projections, respectively supporting the condyles, and called the *external*

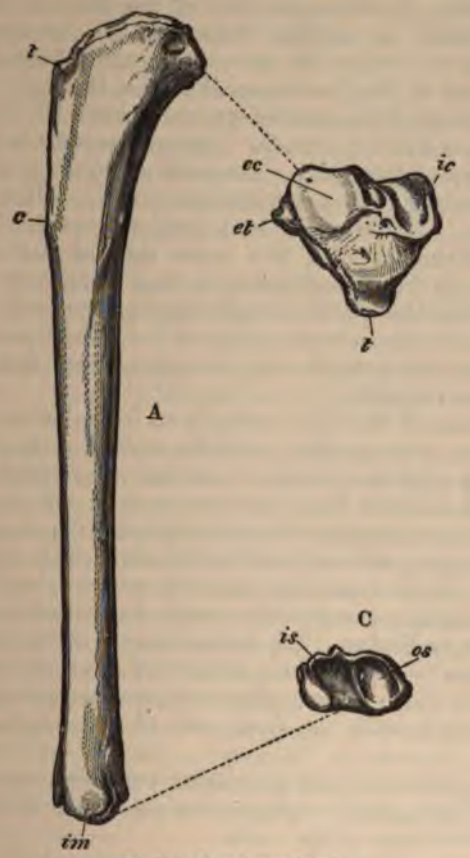


Fig. 71.—THE RIGHT TIBIA.

A. Inner surface. B. Its proximal end. C. Its distal end.

EXPLANATION OF LETTERS IN FIGS. 69, 70, AND 71.

t.
rnal condyle.
. 69, B). Is the external malleolus, the der surface of which is grooved for the don of the peroneus brevis muscle.
. 70, B). Is that surface of the external leolus, which articulates with the fibula.
rnal tuberosity.
ened surface for fibula below.
ace for fibula above.

ic. Internal condyle.
im. Internal malleolus.
is. Inner surface for astragalus.
it. Internal tuberosity.
os. Outer surface for astragalus.
p. Descending process.
t. Tuberosity.
Between *im* and *p* (Fig. 70, A) is the groove for the tendon of the flexor longus hallucis muscle.

internal tuberosities (*et* and *it*). The external one presents th a very small elongated surface for articulation with the part of the fibula (*fs*).

The shaft of the tibia is generally triangular in section, being produced into a sharp *crest* (*c*) in front, on the internal side of which crest the bone is more or less flattened, while it is strongly concave on its outer side. At the upper end of the front of the shaft is a prominence called the median *tuberosity* (*t*), or *tubercle*, which exhibits a flattened surface for the attachment of the patella.

The lower end of the bone is smaller than the upper. Its lower border has a single wide, vertical groove behind for the tendon of the flexor longus hallucis muscle. Its outer surface is flattened (*fi*) for the reception of the fibula. Its inner margin is produced downwards into a strongly marked triangular process, called the *internal malleolus* (*im*). This forms the bony projection on the inside of the ankle, and articulates with the inner side of the tarsus. The posterior part of the non-articular, or free, surface of the internal malleolus, shows two small strongly marked vertical grooves, the anterior of which transmits the tendon of the tibialis posticus muscle, while the more posterior and outer is traversed by that of the flexor longus digitorum muscle.

The lower end of the tibia presents an irregular and undulating articular surface, corresponding with the surface of the tarsus, which it joins. This surface presents a median ridge running obliquely backwards and inwards from its front margin, and fitting into the groove on the upper surface of the astragalus. On the outer side of the ridge is a rather wide articular surface (*os*), which slopes upwards and outwards; on its inner side is a more concave, but less inclined surface (*is*), which becomes continuous with the articular surface borne by the internal malleolus. The hinder margin of the articular surface of the tibia (when the bone is vertical) descends slightly below its front border, which nevertheless exhibits a descending process (*p*) which corresponds with the front end of the median ridge just described.

§ **16.** The FIBULA is the slenderest bone, in proportion to its length, in the body, and extends on the outer side of the leg from close to the knee down to the ankle.

Its upper extremity is slightly enlarged into what is called the head, which articulates with the outer side of the head of the tibia, and gives insertion to the external lateral ligament. It does not mount upwards so high as does the tibia, and its outer surface is concave.

The shaft of the bone is irregularly triangular in section. Its lower end is expanded into what is called the *external malleolus*, which forms the bony projection on the outer side of the ankle, and articulates with the outer side of the tarsus.

This malleolus does not project downwards so far as does the internal malleolus. On its inner side it articulates anteriorly with the outer side of the lower end of the tibia (as already mentioned) below and behind this it articulates with the outer side of the astragalus. The external malleolus is deeply grooved behind for the passage of the tendon of the *peroneus brevis* muscle, while that

of the peroneus longus muscle passes in front of the external malleolus.

Thus, altogether we have at the lower end of the cat's leg, a median horizontal surface for the tarsus, with two other articular surfaces, at right angles with the horizontal one, and formed by the surfaces of the malleoli.

§ **17.** The TARSUS consists of seven bones (none of which can be called "long bones"), namely the astragalus, calcaneum, cuboides, naviculare, and three cuneiform bones. All these are so firmly connected by ligamentous fibres which envelope them, that very little mobility is possible, though there may be a very slight rotation of the distal tarsal bones upon the proximal ones, that is, upon the astragalus and calcaneum.

The movement of the foot on the leg, however, takes place entirely by the hinge-like joint by which the tarsus articulates with the bones of the leg.

The *astragalus* receives the weight of the trunk from the tibia, and is a short irregularly shaped bone (Fig. 73, *as*), with a "body, neck, and head."

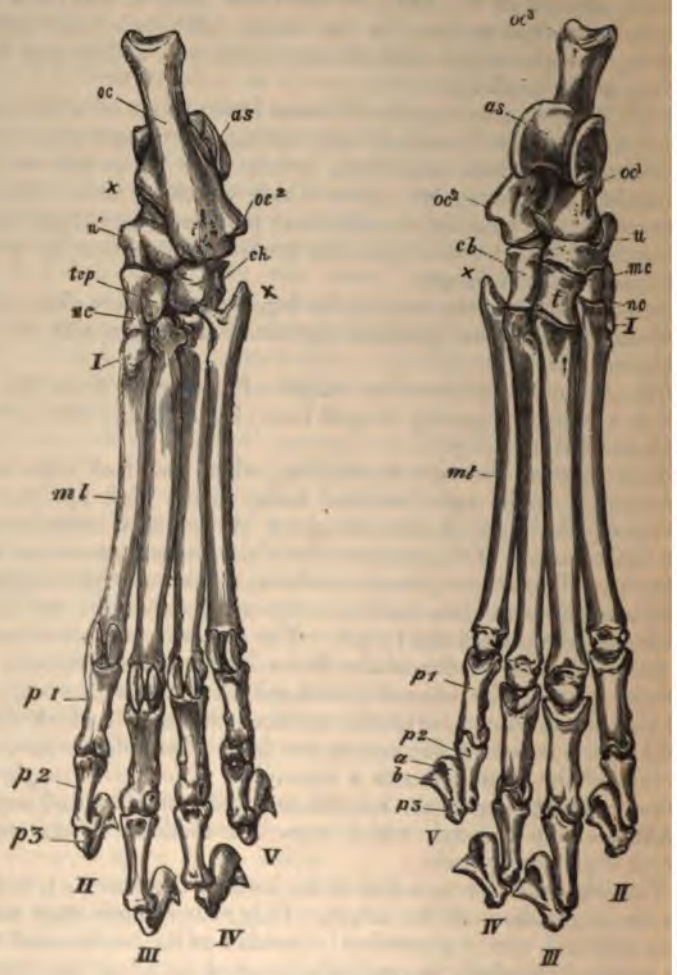
In its natural position in walking, when the foot rests on the ground only by its toes (the heel being raised high up) the upper surface of the body of the astragalus (by which it articulates with the under surface of the shaft of the tibia) looks forwards as well as upwards. Two other articular surfaces, almost at right angles with the former, join the two malleoli respectively, that for the internal malleolus being much the larger. The posterior surface of the body is grooved for the tendon of the flexor longus hallucis muscle. The anterior part of the bone is prolonged forwards as its neck, ending in a rounded, convex, articular surface (the head), which fits into the hinder surface of the naviculare (*n*). The anterior part of the dorsum of the bone presents a concavity, which gives origin to the extensor brevis digitorum muscle, and also affords attachment to a tendinous loop through which pass the tendons of the extensor longus digitorum muscle.

The *calcaneum* (or *os calcis*) is the bone of the heel (*oc*), and is by far the largest bone of the tarsus. It is rather more than twice as long as broad, and is somewhat expanded at its hinder end (called its tuberosity), which is vertically grooved to allow the tendon of the Plantaris muscle to play over it (Fig. 72, oc^3). The calcaneum articulates with the astragalus above and with the cuboid in front. It developes a process on its inner side (*x*) to support part of the last-named bone, and another smaller process (oc^2) on its outer side just before joining the cuboids.

The *naviculare* (or scaphoid of the foot) is, on its dorsal surface, wider than long (Fig. 73, *h*). Behind, it is deeply concave for the reception of the head of the astragalus. In front it presents three surfaces for articulation with the three cuneiform bones. That for the middle one is convex.

Its inner margin sends backwards a long process, called its

tuberosity, which extends (*n'* and *u*) beneath (*i. e.*, on the plan side of) the head of the astragalus and supports it.



BONES OF RIGHT HIND-PAW.

Fig. 72.—Plantar Surface.

a. Hood to enclose root of claw.
as. Astragalus.
b. Process to sustain claw.
cb and *ch*. Cuboides.
oc. Os calcis.
*oc*¹. Inner process.
*oc*². Outer process of os calcis.
*oc*³. Groove for tendon of Plantaris.
mc. Meso-cuneiform.
mt. Metatarsals.
n'. Tuberosity of Naviculare, as seen on the plantar surface.
nc. Ento-cuneiforme.
*p*¹. Proximal phalanx.

Fig. 73.—Dorsal Surface.

*p*². Middle phalanx.
*p*³. Distal phalanx.
t. Ecto-cuneiform.
tcp. Its hooked plantar process.
u. Tuberosity of naviculare, as seen on d surface.
× (Fig. 72) inner process of os calcis.
× (Fig. 73) the tuberosity of fifth metatars
I. Hallux, only represented by its metatar
II. Index.
III. Medius.
IV. Annulus.
V. Minimus.

Of the three cuneiform bones, the outermost one—*ecto-cuneiform*, is the largest, and the *meso-cuneiform* is the smallest, and is not to be seen on the plantar surface of the foot. The *ento-cuneiform* is longest from behind forwards. It presents behind a concave articular surface for the naviculare. Above it has posteriorly a concave articular surface for the meso-cuneiform, and anteriorly a much smaller one for the second metatarsal. In front it has a flat surface (elongated from the dorsum to the plantar aspect) for the rudimentary first metatarsal. The *meso-cuneiform* is a wedge-shaped bone with its broad end on the dorsum of the foot. Behind it presents a concave articular surface for the naviculare, and it has another concave articular surface in front for the second metatarsal. The *ecto-cuneiform* has both in front and behind a large articular surface, broad dorsally, and narrow towards the plantar surface. The former articular surface is for the naviculare, the latter for the third metatarsal. It has also on its inner side a small articular surface for the meso-cuneiform, and on its outer side a much larger one for the cuboides. The hinder, or proximal part of its plantar surface sends downwards and distally a strong hook-shaped process (*tcp*), between which and the plantar surface of the bone, the tendon of the *peroneus longus* muscle passes.

The *cuboides*, placed on the outer side of the tarsus (*cb*), articulates with the os calcis behind, and with both the fourth and fifth metatarsals in front. Its inferior surface is traversed by a deep groove (for the tendon of the *peroneus longus* muscle), behind which is a prominence for the attachment of a ligament.

§ 18. The METATARSUS consists of four elongated bones (the shortest of them being more than half the length of the radius), and one excessively short and rudimentary one (I) which is placed on the inner or tibial side of the other four.

The four long metatarsals are much more elongated than are the corresponding metacarpals, and the second of them (that of the third digit or medius of the foot) is also much stouter than is any one of the latter.

The innermost metatarsal is the only bone which represents the first or innermost digit. It is called the *hallux*, and corresponds with the pollex of the fore-paw. This first metatarsal is a minute conical bone, smaller even than the meso-cuneiform. It has an oblique articular surface at its proximal end, which articulates with the ento-cuneiforme, while on its inner side is another articular surface for the second metatarsal.

The four outer metatarsals have their bases or tarsal ends enlarged, and each provided with a proximal articular surface (different in shape in each metatarsal) for the tarsus, situated in a plane nearly at right angles with the long axis of each respective metatarsal. The proximal articular surface of the second metatarsal is small and triangular; that of the third is very large and crescentic; that of the fourth is moderate in size and quadrangular; that of the

fifth is very small and oval, and with a long process or tuberosi extending backwards on its outer side (*x*).

The shafts of the four outer metatarsals are flattened dorsally a on their plantar surface, and where they are in contact towards the proximal ends. That of the medius is the longest and the stoutes that of the fifth digit is the most slender, and that of the index the foot, the shortest. Each of these four outer metatarsals develo a rounded head at its distal end, which articulates with the concavit on the hinder end of the proximal phalanx of the correspondin digit. As in the corresponding part of the metacarpals, there is prominence developed at the middle of the ventral surface of eac such distal, articular head—a sesamoid bone playing in the concavit which exists on each side of such prominence.

§ **19.** The PHALANGES are three in number in each digit, excep the first or hallux, which is devoid of any.

In form and arrangement the phalanges of the hind-foot closel resemble those of the fore-foot, except that the proximal ones of th outermost (peroneal) digits are longer and stouter.

§ **20.** The ARTICULATIONS AND LIGAMENTS OF THE PELVIC GIRDL are as follows:—

In the first place, each ilium is united to the adjacent auricula surface of the sacrum by cartilage which there coats both bones, an forms what is called the *sacro-iliac synchondrosis*. Ligaments calle the *dorsal* and *ventral sacro-iliac ligaments* strengthen this articula tion on each side. The pubes are joined together at the symphysis b the help of a fibro-cartilage, and by *superior* and *inferior ligaments*.

The obturator foramen is closed by means of the *obturator mem brane* (or ligament), which is attached to its margin or inner edge.

The socket offered by the bony pelvis to the head of the femur i deep, but it is made still deeper by the *cotyloid ligament*, whic surrounds its margin and bridges over the notch at its lower part forming there what is called the *transverse* ligament.

The movements of the thigh, therefore, though still extensive, are more restrained than those of the fore-limb at the shoulder-joint. The head of the femur is held in its socket in part by a very strong ligament called the *ligamentum teres*, which is at one extremity continuous with the transverse ligament, while at its other end it i inserted into the pit on the head of the femur.

The joint is surrounded by a *capsular* ligament, strongest in front attached above to the margin of the acetabulum and the transverse ligament, and below to the intertrochanteric line in front, but at a higher level behind. It is lined by synovial membrane.

The ARTICULATIONS AND LIGAMENTS OF THE HIND-LEG are ex ceedingly complex.

The *internal lateral ligament* (Fig. 74, *i*) extends from the interna tuberosity of the femur to the inner tuberosity of the tibia. Th tendon of the semi-membranous muscle (*sm*) passes between it an the bone.

The *external lateral ligament*, very strong and distinct (*e*) passes as a flattened cord from the external tuberosity of the femur to the head of the fibula.

The *posterior ligament* (*p*) is a narrow band extending obliquely upwards from the outer part of the summit of the tibia to the internal condyle of the femur.

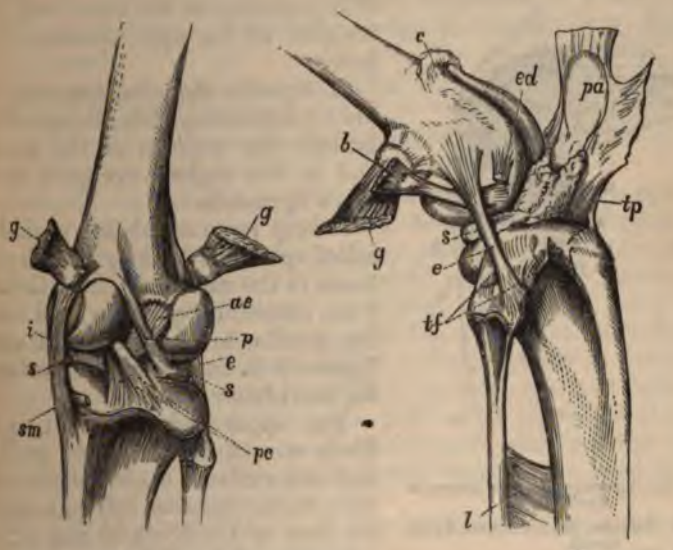


Fig. 74.– LIGAMENTS, WITH SOME MUSCULAR INSERTIONS, OF THE KNEE-JOINT.

A. Seen posteriorly.
B. Seen externally.
ae. Anterior crucial ligament.
b. *Biceps* muscle.
c. Upper attachment of capsular ligament.
e. External lateral ligament.
ed. *Extensor longus digitorum*.
g. *Gastrocnemius*.
i. Internal lateral ligament.
l. Inter-osseous ligament.
p. Posterior ligament.
pa. Patella.
pc. Posterior crucial ligament.
s. Inter-articular cartilage.
sm. *Semi-membranosus*.
tf. Tibio-fibular ligament.
tp. Ligament of the patella towards its insertion.

The *ligamentum patellæ* (*tp*) is a strong fibrous band proceeding upwards from the anterior tubercle of the tibia to the lower end of the patella. The patella (*pa*) is supported above by the tendon of the rectus muscle which is inserted into it, and indeed, the ligamentum patellæ may be viewed as the inferior termination of that tendon, and the patella itself as a large sesamoid bone. This ligament aids powerfully in preventing the flexion of the knee forwards, there being in the leg no process like the olecranon of the ulna to prohibit (by the mere shape of the leg-bones themselves) a bending of the joint in the wrong direction.

Two other fibrous bands, termed the *crucial ligaments*, are placed in the centre of the knee-joint, and slightly cross each other, whence their name. The anterior (or external) one (*ae*) goes from

the pit between the condyles of the tibia to the inner and posteri part of the external condyle. The posterior (or internal) one (*p* goes from a more posteriorly situated part of the same pit to th front part of the concavity between the condyles or the outer side the inner condyle. Two fibro-cartilaginous crescentic structures (*s* the *semi-lunar* cartilages, are inter posed between the femur and th tibia, reposing on the outer and inne margins of the upper surface of th latter.

Fig. 75.—VERTICAL SECTION THROUGH KNEE-JOINT.

- *a*. Anterior crucial ligament (cut short).
- *b*. Bursa.
- *c, c, c*. Capsular ligament.
- *f*. (Above) femur.
- *f*. (In the joint) adipose tissue.
- *lp*. Ligament of the patella.
- *p*. Posterior crucial ligament.
- *pa*. Patella.
- *s*. Inter-articular cartilage.

A *capsular ligament* surrounds the knee-joint incompletely, being deficient beneath the tendons of the muscles, and in the regions occupied by the other ligaments.

A very large membrane of the kind called *synovial* (the largest such membrane in the cat's body) lines the knee-joint, extending up above (and within) the patella, and investing the crucial ligaments in front, and both surfaces of the semi-lunar cartilages.

The upper ends of the tibia and fibula are connected by two small flat and oval surfaces, bound together by a *tibio-fibular ligament* (*tf*) passing from the head of the fibula to the external tuberosity of the tibia.

An *inter-osseous membrane*, or ligament (*l*), passes from the external ridge of the tibia to the adjacent surface of the fibula. It does not ascend quite to the summit of the interval between the leg-bones.

The ARTICULATIONS AND LIGAMENTS OF THE FOOT are so closely connected with those of the inferior ends of the leg-bones that these latter may best be described with the former.

The ANKLE-JOINT is strengthened by *anterior* and *posterior* ligamentous bands.

The *internal lateral ligament* of the ankle-joint passes down (broadening as it descends) from the end of the internal malleolus somewhat to the astragalus and oscalcis, but especially to the tuberosity of the naviculare.

The *external lateral ligament* also radiates as it descends from the lower end of the fibula to the os calcis. The internal malleolus descends somewhat below the external one, and the tibia descends a little more behind the astragalus than it does in front of it.

A certain amount of motion is possible between the distal tarsus and the astragalus and os calcis—a movement facilitated by the presence of synovial membrane.

A strong interosseous *ligament* proceeds vertically downwards from the groove on the under surface of the astragalus to the depression on the dorsum of the os calcis.

A plantar ligament, called the *calcaneo-sesphoid*, connects the plantar surface of the naviculare with the os calcis, and so helps to sustain the anterior part of the astragalus. Another ligament, called the *long plantar*, joins the under surface of the os calcis with the cuboid and tuberosity of the fifth metatarsal. A variety of other ligaments connect one with another the various more distally situated tarsals.

The metatarsal bones are connected with the distal tarsals by dorsal and plantar ligaments.

A *transverse metatarsal ligament* connects the distal ends of the metatarsals as in the fore-foot.

Ligaments connect the metatarsals with the phalanges, and the phalanges with one another in the hind-foot in the same way as the metacarpals and phalanges are severally connected in the fore-paw.

§ **21.** A GENERAL VIEW of the pelvic appendicular skeleton of the cat shows us that it forms a complete bony girdle, being immediately attached (at the sacrum) to the axial skeleton dorsally. Ventrally its two sides meet together uninterruptedly at the pubic symphysis, and there are two ventral bars, the pubis and ischium, instead of only one, and that incomplete, as in the pectoral arch. The knee-joint is so bent as to open backwards, and thus the digits of the hind-foot are applied to the ground without the need of any pronation of the limb-bones.

The skeleton of the leg and foot is divisible into a tri- and bi-digital series placed side by side.

Thus there is first the tibia; the astragalus and naviculare; the three cuneiform bones; the first, second, and third metatarsals, and the index and middle digits—forming the tri-digital series.

We have secondly, the fibula; the calcaneum and cuboid; the fourth and fifth metatarsals; and the annexed digits—forming the bi-digital series.

§ **22.** Thus it is evident that there is a GREAT CORRESPONDENCE, and at the same time a certain DIFFERENCE, between the skeletons of the pectoral and pelvic limbs.

The most notable correspondences are the expansion of the dorsal bone of each limb-girdle; the existence of a single bone with two eminences (tuberosities or trochanters) in the proximal limb-segment, and of two bones in the distal limb-segment; the agreement in number of the carpal and tarsal bones, of the metacarpals and metatarsals, of the epiphysial ossifications of these, and the correspondence in number of the phalanges, except those of the pollex and hallux.

Thus these limb-skeletons are evidently modifications of one type.

The most notable differences are (1) as regards the dorsal attachments of the limb-girdles, and (2) the degree of complexity of their ventral parts; (3) the fact that the outer or radial tuberosity in the

humerus is the larger, while in the femur it is the inner or peroneal one; (4) that the ulna is the larger bone in the arm, while the fibula is much the smaller in the leg; (5) that the ulna is the main element of the elbow-joint, while the fibula is excluded from the knee-joint; (6) that the ulna sends up a very large process (the olecranon) at its proximal end, while the fibula sends up no process at all; (7) that in the knee-joint there is a patella, while there is no such structure in the elbow-joint; (8) that the tarsus is grasped between the malleoli, while so complete a grasp is not given by the arm-bones to the carpus; (9) that there is no bone so large, either absolutely or relatively, in the carpus, as is the os calcis in the tarsus; (10) that the pollex rests on a saddle-shaped surface, and is slightly separable from the other digits, while the rudimentary hallux rests on a nearly flat surface, and has almost no mobility; (11) that the metatarsals are long as compared with the metacarpals; (12) that the tarsus is much longer than is the carpus; (13) that the hallux is much more rudimentary than is the pollex.

Though many of these differences are incapable of reduction, yet others disappear, and SERIAL HOMOLOGIES become more manifest, if the limbs be placed in that position which is primitive in development, *i.e.*, if both the knee and elbow be turned outwards. Then the pollex and hallux, and the ulna and tibia, stand in corresponding positions in relation to the long axis of the body.

As to which parts of the os innominatum answer to the several parts of the scapula, different views may be maintained; but if the lower end of the scapula be rotated outwards, then its subscapular fossa will be seen to answer to the gluteal surface of the ilium, the acromion to the ischium and the coracoid to the pubis, the infraspinatus and iliac fossæ corresponding.

Undoubtedly the femur, is the serial homologue of the humerus, and its great trochanter, of the lesser tuberosity; the radius, of the tibia; the ulna, of the fibula; the astragalus, of the scapho-lunar bone; the ento-cuneiform, of the trapezium; the cuboides, of the unciform, and the hallux and other pedal digits are the homologues of the pollex, and the other digits of the hand.

§ **23.** Such being the main facts as to the structure of the internal skeleton, before concluding the subject a few words are needed with respect to the JOINTS. For, as has been already pointed out, the bones serve as points of attachment for the moving organs or muscles which make use of them as so many levers or fulcra, as the case may be.

In order that this motion of the bones may take place easily, the interposition is required of certain accessory structures between bony surfaces which move one upon the other. Some bones, however, are united by surfaces which join without any such intervention—no motion taking place at the line of junction of such bones.

JOINTS may be of three sorts: I. immovable; II. mixed; or III. movable.

The IMMOVABLE joints (synarthroses) may be (1) such as those

which take place between certain bones of the skull where, as we have seen, an interdigitation of the processes of their irregularly-shaped margins takes place, forming what is called a *dentated* or *serrated suture* (as between the parietals or frontals); or (2) such as those between the upper jaw-bones, where there is no interdigitation, and where the adjoined even edges form what is termed an *harmonia* or false suture; or (3) such as that formed by the temporal bone with the parietal, where the adjacent margins are bevelled off and one overlaps the other, forming what is called a *squamous* suture; or (4) such as that between the ethmoid and the vomer, where a ridge of one bone is received into a groove in another which is called *schindylesis*; or finally (5) where one hard part is received into the cavity of a bone, as the teeth fit into the jaws, a mode of union named *gomphosis*.

In all the immovable joints no cartilage is interposed, there being only periosteum, such as coats all bones.

The great majority of the bones, however, are intended to move one upon another, and are on that account joined together by means of some other and thicker substance than the periosteum.

The MIXED or imperfect joints (*amphiarthroses*) have, however, very little mobility, and their adjacent parts do not present smooth surfaces, but are connected by fibrous tissue or continuous cartilage, or both.

Examples of such joints are to be found in the junction of the haunch-bones with the spine, or in that formed by the bodies of the vertebræ one with another. These latter are connected, as we have seen, * by discs, each consisting, towards its circumference, of fibres running obliquely upwards and downwards, and in its middle, of a pulpy substance containing many cartilage corpuscles. These pads, while allowing very little movement between any two adjacent bones, give a considerable amount of mobility to the whole series. They also serve to prevent shock.

In all MOVABLE or *complete* joints (*diarthroses*) the opposed ends of the bones are covered each with its own distinct, separate, and very smooth cartilage, and thus the bones can glide freely on each other.

In addition to this, however, each complete joint is provided (as has been already indicated in various instances) with a kind of bag containing a viscid fluid. This bag, at first complete, comes in adult life to be attached to each of the cartilaginous surfaces, near its border, and to disappear altogether over the central part of each such cartilage. By the fluid thus interposed between the cartilages all friction is avoided, and a perfectly smooth, easy, and even motion is provided for.

The fluid is termed SYNOVIA, and is an albuminous liquid commonly called "joint-oil," yet it is not really of an oily nature, although it contains some fatty matter.

* See *ante*, p. 52.

The bag, formed of areolar tissue lined with scaly epithelium, is called the SYNOVIAL CAPSULE or membrane. It is more or less connected with the fibrous bands, or ligaments, which bind the bones together in the neighbourhood of the joints and generally help to restrain movement to certain directions.

In certain joints, as in that of the cat's knee, additional structures are interposed, called INTER-ARTICULAR CARTILAGES. These are formed of fibro-cartilage, and, though placed between the bones, are not within the cavity of the synovial sac, but attached to its outer surface, which is so folded or doubled as to embrace them.

Movable joints are of different kinds, with corresponding diversities of form. Thus they may be such that the bones are capable of nothing more than a slight gliding movement one on the other, the apposed articular surfaces being nearly flat and even. Such joints are termed PLANIFORM, or ARTHRODIA, and as examples may be selected the bones of the carpus and tarsus.

A second kind of joint is that called BALL-AND-SOCKET, or ENARTHRODIA, where one rounded portion of bone is received into a corresponding cup or *socket*. When the cup is very deep, the cavity is said to be *cotyloid*—as in the hip-joint; when it is shallow, it is said to be *glenoid*, as in the shoulder. The shallower is the cavity, the freer and wider is the power of motion. If the terminal convexity is elongated it is termed a condyle—as is the articular head of the lower jaw.

A third and a more complex kind of articulation is called a HINGE or GINGLYFORM JOINT, and is also called *pulley-like* or *trochlear*. In such joints the surface of one bone is more or less cylindrical, and fits into a corresponding socket. The former generally exhibits a median groove with a projection on each side of it, while the other bone has a corresponding median prominence bordered by two concavities; but various arrangements of opposing curves may exist, tending to limit motion more or less completely to one plane. The best example of such a joint is that of the elbow, a more imperfect one is that of the knee. This kind of joint may be so complicated as to form what is called a *double hinge-joint* (as between the metacarpal of the pollex and the trapezium). In that articulation each bone is concave in one direction, and convex in the direction at right angles with the former, that is to say, each bone presents a *saddle-shaped* surface, and the two articulate together, as a rider is placed with respect to the saddle he bestrides.

There is another kind of joint, rarely found, and termed a RING and COLLAR-JOINT, or *lateral ginglymus*. It is when the head of a bone is received into a strong ring or collar, formed of ligament, which allows the bone to rotate round its own axis. Such a joint exists between the upper (proximal) parts of the two bones of the fore-arm.

The last kind of joint to be noticed is that called a PIVOT-JOINT, an example of which is furnished by the two uppermost bones of the neck. Here one bone serves as an axis or pivot on which the other

can rotate. It resembles in principle the joint last noticed, but here the part bearing the ring (which ring is formed partly of bone, partly of ligament) itself turns on the bone, which traverses it instead of the reverse.

Certain ligaments are called ELASTIC LIGAMENTS, because they contain elastic tissue, and so serve to sustain weight, and overcome persistent resistance, without the necessity of expending any muscular power. Such are the ligaments between the neural arches of the vertebræ and their continuation onwards to the occiput (to support the head), as the *ligamentum nuchæ*.

CHAPTER V.

THE CAT'S MUSCLES.

§ 1. The cat performs conspicuous general bodily movements—locomotive actions, such as walking, running, and jumping—and also a number of movements of various portions of the body. Some of its movements resemble those which are executed by ourselves at will, and therefore called "voluntary motions;" others resemble those which we know to be in ourselves automatic, or involuntary.

Amongst the *voluntary* movements are the various movements of the several members, such as the tail, the tongue, &c., together with those by the aid of which the animal may change its facial expression, or may give audible expression to its various feelings.

Amongst its *involuntary* or *automatic* movements are those which we shall find take place in the heart, intestines, and in other viscera.

All these motions, of whatsoever sort, are performed by muscles of different kinds, shapes, and sizes.

It is of muscles that the bulk of the cat's body—that is to say, all its "flesh"—is formed. The muscular system, therefore (by investing the endo-skeleton as it does), largely determines the shape of the trunk and limbs, though its essential function is the production of *motion*.

The study of the muscles is called MYOLOGY.

The muscular system of the cat consists of masses of very different sizes and shapes, arranged in most various aggregations of muscles, such aggregations being separated from each other by delicate sheets of connective tissue called *fasciæ* or *aponeuroses*. Yet more delicate fibrous membranes invest every single muscle, and penetrate between its component portions, conveying nerves and blood-vessels to them.

Other skeletal structures with which the muscles are directly connected, are those dense bands of connective tissue already referred to as "tendons."

§ 2. Muscular substance constitutes a peculiar kind of *tissue*. It is a *motor tissue* because it has the power of producing motion by "contraction," that is, by an alteration in its shape which affects the parts of the body to which it is attached. It has also a special chemical composition. It is made up for nearly three-fourths of

its substance of water, while about fifteen per cent. of the remaining fourth is found, after death, to consist of an albuminoid substance called *syntonin*, or *muscle fibrin*,* which is soluble in dilute hydrochloric acid. It seems, however, that this post-mortem condition differs from what is found in life, when the muscle-fibrin is fluid, and has been termed *myosin*. Muscle-fibrin contains some fifteen per cent. of nitrogen. Other nitrogenous substances termed *kreatin* and *kreàtinine*, are present in very small quantities, as also some non-nitrogenous ones, such as grape-sugar, lactic, butyric, acetic, formic, and uric acids, with some other substances.

Muscular tissue is of two kinds, called respectively STRIPED and UNSTRIPED. The unstriped tissue takes part in the formation of the alimentary canal and other viscera, such as the bladder. It also exists in the walls of the blood-vessels, and generally in parts the actions of which, in man, are not under the control of the will Striped muscular tissue, on the contrary, makes up the substance of all those muscles which answer to such as in us are amenable to the will, together with some parts which act involuntarily—as the heart. This striped kind is the more complex in structure.

UNSTRIPED MUSCULAR TISSUE, as the more simple, may be first noticed. It is pale, translucent, and made up of a number of roundish or flattened fibres from the $\frac{1}{3000}$ to the $\frac{1}{7000}$ of an inch in breadth, devoid of any limiting membrane, more or less fusiform in shape, and marked at intervals with oblong corpuscles. Each fibre is made up of bodies termed *muscular fibre cells*, of an oblong, flattened shape, of a granular substance, and containing an oval or rod-shaped nucleus. The nuclei become very distinct when the fibres are treated with dilute acetic acid. As well as forming fibres, those cells may be mixed up with other tissues, as, *e. g.*, in the dermis (where some of them, by their contraction, may make hairs "stand on end" in the way before spoken of), or they may form broad layers of interlacing fibre-cells. They are never attached to bones. Sometimes they bifurcate at one end.

STRIPED MUSCULAR TISSUE consists of fibres which are generally collected in larger or smaller bundles termed *fasciculi* (Fig. 76, A), each fasciculus being furnished by a membranous envelope sent inwards from the sheath, or *perimysium*, which invests the whole muscle, except in the heart, where the fibres are naked. Each fibre (B) has a membranous transparent investment called the *sarcolemma* (Fig. 76, B *e*), which is of the nature of elastic tissue. The fibres average about $\frac{1}{400}$ of an inch, but may be somewhat larger or much smaller.

Within the wall of the sarcolemma, there may be at intervals elongated corpuscles, but the special characteristic of fibres of this tissue is

* Fibrin is the name given to the soft, whitish, stringy substance, which may be obtained from fresh blood by whipping it with fine rods. It is very like albumen, but differs by its property of spontaneous co-agulation. See the description of the blood, Chapter VII., § 2.

the appearance of a number of alternating, exceedingly regular, transverse markings, such *striation* depending on a regular arrangement of alternate parts with different refractive properties. Each striation

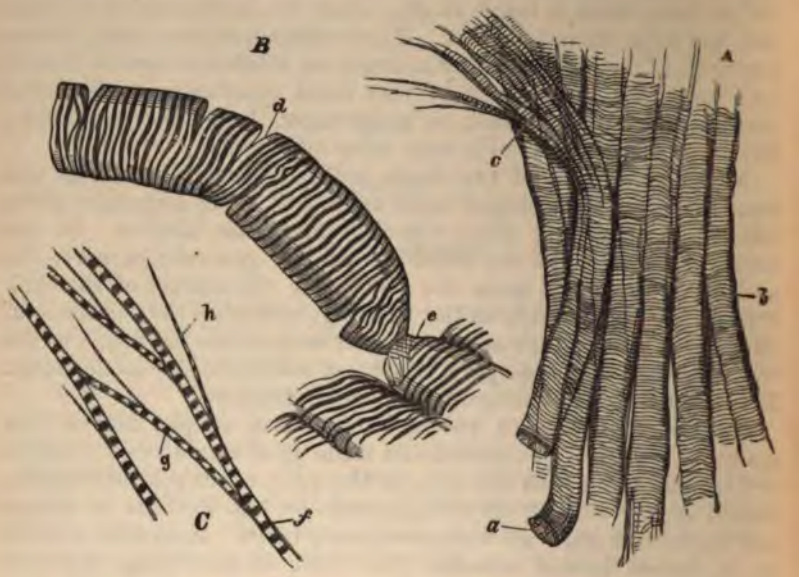


Fig. 76.—Striped Muscular Tissue of the Cat, greatly magnified.

A. Bundle or fasciculus of fibres.
a. Cut end of a fibre.
b. A fibre.
c. A fibre broken up into its component fibrils.
B. A fibre, with parts of two others. The fibre has been split at right angle to its long axis.
d. One of the clefts.
e. Investing membrane or sarcolemma, seen at a point of rupture. The sarcolemma is twisted, but not broken.
C. Fibrilla of different magnitude (*f*, *g*, *h*,) very greatly enlarged.

consists of a central narrow dark line (the *septal line*), on each side of which is a narrow transparent space (the *septal zone*), while between the transverse striations is a much larger space (the *interseptal* zone), and these larger parts constitute the main substance of the fibre and therefore of the muscle. The appearance thus presented is that of a number of opaque discs embedded, at regular intervals, in a more translucent substance.

Faint indications of longitudinal division may also be detected, and after immersion in alcohol, or a weak solution of chromic acid, each fibre may be broken up into a number of very much more minute ones termed fibrillæ (Fig. 76, C), each fibril still presenting the transverse striation. It is, however, by no means sure that each fibre is really made up of naturally distinct fibrillæ, since, when treated with much diluted hydrochloric acid each fibre may be broken up into (B *d*) a number of thin discs, parallel to and coinciding with the transverse striations. In the heart, the fibres are branched.

§ 3. Muscular contraction (which takes place under certain

conditions and excitations), not due to any mere physical or chemical change, but is a vital action. The capability of being acted on by such excitations is called *irritability*, and the special form of irritability possessed by muscle is called CONTRACTILITY.

This contractility may be seen to act in a single fibre, and it is by the simultaneous action of the fibres composing it that each muscle performs its proper function, and *contracts* as a whole.

The change of shape referred to, is a temporary shortening of the fibres in length, with a consequent transverse enlargement. It is a familiar fact that when, in ourselves, the fore-arm is bent upwards a temporary swelling takes place on the front of the upper arm. This is due to the thickening which accompanies the shortening of the muscle mainly employed in effecting such movement.

The contracted state of any muscle can only endure for a limited period, and cannot be repeated without an interval of rest, which must be greater according to the exhaustion induced by frequently repeated contractions. There is one muscle, however, which acts throughout the whole of life, the contractions being continually reiterated after short regular intervals of rest. This muscle is the heart, which takes its needful interval of repose after each contraction.

Unstriped muscle contracts slowly and but slowly relaxes, while striped muscle can contract suddenly and be suddenly relaxed. In certain pathological states, as, *e.g.*, in lockjaw, muscular contraction may be greatly prolonged.

The amount of force with which a muscle contracts depends on the number of its fibres, but the length of the muscle determines the degree of shortening which can be effected.

The irritability of muscular tissue persists for a certain period after death, which varies somewhat according to the cause of dissolution—speedily disappearing after death from poisoning by noxious vapours, or from lightning, while occasionally it has been found in man to persist for twenty-four hours after death. Sixteen hours, however, is the ordinary limit, even of that part of the heart (the right auricle) which was called by Galen the "ultimum moriens," on account of its long-enduring irritability. This property persists very much longer in cold-blooded animals, *e.g.*, the frog.

The agent which induces muscular contraction is called a stimulus, and there are various kinds of STIMULI.

Thus, there may be a direct stimulus, such as the application to the muscular fibres of a sharp-pointed body, or of an acid or some acrid substance, or by sudden heat or cold, or by a shock of electricity.* There may also be an indirect stimulus, *i.e.* when the excitation is applied not directly to the muscular tissue, but to the nerves distributed to it, or there may be a mental stimulus due to emotional excitement. Stimuli, physically equal, have a more powerful effect when acting on a muscle through a nerve, than when acting directly on the muscle itself.

* The resistance of a muscle to electrical conduction is seven times as great transversely as it is in the direction of its length.

Shortly after death a peculiar rigidity of the muscles soone: or later sets in, which may be so intense that rupture of tissue will take place rather than change of posture, if force be applied to produce the latter. This is the death-stiffening, or *rigor mortis*.

This rigidity does not alter the position in which the limbs may happen to be when it sets in.* It appears to be due to a solidification (coagulation) of the fluid substance of the muscular tissue.

The occurrence of rigor mortis is a certain proof that death has taken place.

§ **4.** Muscular fibres being thus aggregated, as has been said, into various masses termed muscles, the number of these masses may be estimated at some 500 in the cat. They vary greatly in size, in weight, in form and in the arrangement of their fasciculi. Generally, the fasciculi are arranged longitudinally in a more or less parallel manner, and end by insertion side by side into a tendon; but sometimes they radiate from a central band of dense fibrous tissue (or tendon) in a *penniform* or *semi-penniform* manner. Sometimes they are arranged in a concentric manner round apertures, when they are called *sphincters*; or in a cylindrical manner, as in the walls of the alimentary canal. They may have, as in the last named instance, no connexion with bone, but generally they are attached to bones which they employ (as we shall shortly see) as levers or fulcra, and are then generally inserted by means of those dense bands of parallel fibres of connective tissue called *tendons*.

The fleshy mass of a muscle is called *the belly*, and there may be two such bellies with an intermediate tendon. Such a muscle is termed *digastric*. A muscle may arise by two or more heads, when it is called *bi-* or *tri-cipital*, as the case may be.

That end of a muscle which is nearest to the central axis of the whole body, or to the root, or axis of the limb of which it forms part, is generally called its ORIGIN, or its "proximal end." The opposite extremity is generally called its INSERTION, or its "distal end."

Muscles acting on bony levers produce definite motions of different kinds, according to the circumstances of their application. This difference of functions causes them to be distinguished by certain generic terms, each such term being applied to all such muscles as produce a motion of the kind denoted by the term.

Thus, muscles which bend a joint so as to make the angle formed by two long bones acute, or which move the digits towards the palmar or plantar surfaces of the feet, are termed FLEXORS. Those the function of which is antagonistic to these are termed EXTENSORS.

Some muscles attached to a long bone which is relatively fixed at one end, tend to make it describe the superficies of a cone, or a movement of *circumduction*. Such muscles are termed ROTATORS.

* Occasionally after death from cholera and yellow fever, distinct movements have been observed in the human subject; but these are probably due to some action of decomposition on parts of the nervous system.

Some muscles move a bone away from a given axis, and are therefore termed *abductors*. Others tend to bring it towards such an axis, and such are called *adductors*. The epithets "*protractors*," "*retractors*," "*elevators*," and "*depressors*," (terms which require no explanation), are also sometimes made use of.

There cannot, however, be any really good classification of muscles according to the functions they execute, because such functions may vary in different animals with regard to the very same muscle.

§ 5. In considering the action of muscles, the SUPPORT OF THE BODY may be first considered. The way in which this is affected varies of course with the posture it may assume. In standing, the basis of support afforded by the four paws is very wide, but the posture cannot be maintained when the muscles are inactive, on account of the flexibility of the joints. It is maintained by the normal contraction (tonicity) of the muscles, which, being placed on opposite sides of the body and of each supporting limb, antagonize each other, and so prevent the joints from flexing, and the body from consequently drooping, collapsing, and falling to the ground, as it does immediately when any sudden cause (such as a violent blow on the animal's head, or shot sent through its heart) suddenly suspends their action.

During waking life, changes of posture, which tend to cause the centre of gravity to fall without the basis of support, are instinctively followed by compensating motions which have the effect of retaining it within such basis. Thus if the left fore-leg be extended outwards to the left, the body instinctively and simultaneously leans, or the tail is thrown, over to the right, and the extreme mobility of the tail in all directions is a great agent in maintaining the equilibrium of the body.

In locomotion the limbs may be used either successively, as in *walking*, or simultaneously as in *springing* and *running*. In leaping, all the joints of the hind-limbs are bent, and these by their sudden unbending give impetus to the body.

In walking, each leg alternately swings forward as a pendulum, the fore and hind-limb of each side being advanced successively and alternately with one of those of the opposite side, as *e.g.*, 1st, left fore-leg; 2nd, right hind-leg; 3rd, right fore-leg; 4th, left hind-leg. Even in walking, however, the impetus is imparted by the hinder limbs, the action of the fore-limbs being mainly that of support.

The part of the foot applied to the ground by the cat does not answer to the sole of the human foot, but only to the toes; the heel being raised much above the ground. Similarly in the fore-foot the wrist is raised and the digits alone support the body. On this account the cat's mode of progression is spoken of as *digitigrade*.

As has been already said, the muscles generally act on the bones, making use of the latter as LEVERS or FULCRA.

The levers used in the cat's body are of all the three orders

known in mechanics. A "lever" consists of a rigid rod, movabl in one plane round a point—the "fulcrum."

The *first order* of levers is where the fulcrum is placed betwee the weight and the motive power.

The *second order* is where the weight to be moved (or resistanc to be overcome) is placed between the fulcrum and the power.

The *third order* is where the power is applied between the fulcrun and the weight or resistance.

In the action of the hind-legs of a cat which is lying on its bac and scratching at an object with its hind claws, we have an exampl of the first order of levers. For thus the muscles of the calf, bein attached to the tuberosity of the os calcis, act on the skeleton of th foot as on a rod resting against the distal end of the tibia as on fulcrum. The other end of this rod (the claw-bearing part) pushe away any object against which it may strike.

The same parts, as employed in walking, may serve as an exampl of the second class of levers. Thus considered, the earth will b the fulcrum, the weight to be moved (the body as resting on th tibia) being placed between it and the point of muscular attachmen —that is where the motive power is applied.

An example of the third order of levers is seen in the action of th cat in raising the fore-paw to strike or to wash the face or ear. Her the paw is the weight, and the fulcrum is the distal end of the humerus The motive-power being applied in the intermediate space, viz. (as w shall see) at the attachment of the biceps muscle to the radius.

§ 6. The CLASSIFICATION of muscles follows naturally that of th parts of the skeleton. Thus we have—

(*a*) Muscles of the exo-skeleton, the skin, and

(*b*) Muscles of the endo-skeleton.

To these it will be convenient to add a third category, namely,—

(*c*) Muscles of the viscera.

The *exo-skeletal* system of muscles may consist of smooth or stripe fibres. Some are large and some very small.

The *endo-skeletal* system is naturally divisible, like the endo skeleton itself, into parts appertaining to the head, trunk, and ta (the axial portion), and parts belonging to the limbs (the appen dicular portion).

The *viscero-skeletal* system of muscles consists of the muscula fibres placed in the walls of the alimentary canal and in a variety tubes or organs (such as the heart, bladder, &c.,) to be hereafte noticed in describing those parts.

Since, however, the muscles of the first category are few i number, while those of the third may be better considered in treat ing of the viscera they help to form, the best practical course her will be to consider the muscles according to the regions of the bod to which they belong—the head and neck, the trunk and tail, an the limbs.

MUSCLES OF THE HEAD AND BACK.

§ 7. The *platysma myoides* is a skin muscle which covers the side of the neck and face. Its facial part invests the bulbs of the vibrissæ and long hairs of the eye-brows.

The *orbicularis oris* is a sphincter muscle, its fibres extending round the mouth in the substance of the lips. The fibres of the upper and lower lip meeting at a symphysis at each angle of the mouth. It is very slightly developed, and is much interrupted medianly above, because the cat's upper lip is divided medianly into two lobes.

The *orbicularis palpebrarum* is a thin muscle, the sphincter of the eye-lids, as it surrounds the eye beneath the skin. It is not attached to any bone except at the inner margin of the orbit, and its fibres are arranged concentrically so as to close the eyelids by their contraction. This muscle adheres intimately to the skin.

The *occipito-frontalis* is a thin, flat muscle, one portion of which is attached to the fascia of the occiput and temporal region, the other to the frontal region, and is connected with the orbicularis palpebrarum.

The *levator labii superioris alæque nasi* is a rather large flat muscle which is connected above with the frontal portion of the foregoing, and thence descends to the upper lip and angle of the orbicularis oris.

The *levator anguli oris* (Fig. 77, *c*) is a small fleshy mass which arises beneath the infra-orbital foramen and descends to the outer ala of the nose and upper lip.

The *pyramidalis* passes downwards from the frontal to the dorsum of the nose.

Compressor naris.—This is a very faintly-marked muscle of fibres extending transversely over the cartilages of the nose.

The *zygomaticus* (*z*) is a small muscle extending downwards from the malar close to the maxilla (when it is continuous with the zygomato-auricularis) to the orbicularis oris, near the angle of the mouth.

The *myrtiformis* is a triangular, rather large muscle extending from the firm tissue enclosed in the upper lip to the side of the nose (*my*).

The cat's ears are very movable, and can be strongly drawn back and folded down close to the head.

A variety of small muscles are inserted into the cartilage of the external ear, or into a narrow, elongated cartilage called the scutiform cartilage, which extends on the surface of the head obliquely forwards and inwards in front of each ear, and slides over the aponeurosis of the temporal muscle.

The *fronto-auricular* (*fa*) is a small muscle extending from the orbit to the ear.

Another is the *temporo-auricular* (*to*) which extends (beneath the front auricularis) from the hinder side of the orbit to the antitragus.*

The *maxillo-auricular* (*mo*), slender and vertical, extends from the mandible behind the condyle to the outer side of the base of the concha.

* For an explanation of the parts of the ear, see Chapter IX., § 26.

Various other muscles act on the ear, which it is not deemed necessary to describe in detail; suffice it to say they may be grouped into muscles which tend to draw the external ear forwards, inwards, or backwards. Certain muscles pass even from the skin to the ear—the *auriculo-cervicalis* from the skin of the front of the neck, and the *auriculo-labial* and the *auriculo-submaxillary* from the lips and from the skin beneath the lower-jaw.

The *zygomato-auricularis* passes from the skin of the cheek and from the zygoma backwards to the pinna of the ear externally. It is in part continuous with the zygomaticus. It draws the ear forwards.

The *Attolentes auriculam* are muscular bundles which pass from the mid-cranial region outwards to the pinna, so as by their contraction to bring the two ears together.

The *retrahentes auriculam* are various muscular (*ra*) bundles which come from the occiput and the cervical region to the pinna, and by their action draw it backwards.

The eyeball, lying in its orbit, is held in place and moved by seven muscles.

The first of this is the *suspensor oculi*, or "choanoid muscle," which arises round the optic foramen, and thence expanding and embracing the eyeball, is inserted into rather the posterior surface of the latter. Its fibres are directed longitudinally outwards, and it is more or less divisible into four parts—one superior, one inferior, one external, and one internal.

External to this muscular cone are four straight and two oblique muscles of the orbit (Fig. 130).

The four straight muscles, or *recti*, also arise round the optic foramen, and thence diverging, are respectively inserted into the upper, inner, lower, and outer sides of the eyeball, whence they are termed *superior, internus, inferior, and externus*, respectively. They are inserted in front of the insertion of the suspensor oculi, and correspond with and are superimposed on the four portions of the latter.

Each rectus muscle is a flattened band of parallel fibres, and pulls the eyeball by its contraction either upwards or inwards, or downwards or outwards. By combining their actions variously, they can move it in any intermediate direction.

The *obliquus superior* is also a long and slender muscle arising near the optic foramen. At the inner margin of the orbit its tendon passes through a fibro-cartilaginous ring (or pulley) attached to the frontal bone, and then bends backwards to be inserted between the upper and the external recti muscles.

The *obliquus inferior* has no pulley, and is the only short muscle of the orbit. It springs from the orbital plate of the maxilla near the lachrymal groove, and passing thence backwards, between the floor of the orbit and the rectus inferior, is inserted into the postero-external aspect of the eyeball.

The two oblique muscles are so disposed as to draw the eyeball forwards and inwards when they act together, and to rotate it in different ways when they act successively. The upper oblique

rotates it from without inwards and from below upwards, and the lower oblique acts in the reverse manner.

We shall hereafter see that different nerves go to certain of these muscles. The choanoid muscle is supplied by the sixth nerve.

The *levator palpebræ* is another long slender muscle arising near (above) the optic foramen. It is inserted into the upper eyelid, which it raises. No analogous muscle depresses the lower eyelid.

The *buccinator* is a thin, delicate muscle extending between the alveolar margins of the jaws on each side of the mouth (Fig. 77, B). Its fibres cross each other near the middle of the muscle, and it is perforated by the duct of the parotid gland. It adjoins internally the mucous lining of the mouth; externally, it is partly covered by the muscle next described.

The *masseter* (*M*) is a short and very thick muscle (in two layers) which arises from the malar and under surface of the front part of the zygoma. Its fibres pass thence obliquely backwards (those of the outer layer, very obliquely), to be inserted into the concave outer surface of the ascending ramus of the mandible. Externally, this muscle is only covered by skin and fascia. Its action is to raise the lower jaw, and is therefore an important agent in mastication.

Each *temporalis* (*T*) covers the side of the skull, almost meeting its fellow of the opposite side at the sinciput. Each arises in two layers, from the side of the skull (from the lambdoidal ridge to the postorbital process of the frontal) and being thick and fleshy, fills up the temporal fossa (to which it gives its name) within the zygoma. Its fibres converge (fan-wise) to its insertion into the coronoid process of the mandible. Its action raises the lower jaw, and thus enables the animal to take a very firm grip of any struggling prey it may have seized.

The *pterygoideus internus* is a strong muscle which arises from the pterygoid fossa. Its fibres descend obliquely forward to its insertion in the inside of the angular part of the mandible. It is close to the masseter inferiorly, being only separated from the latter beneath the margin of the mandible, by aponeurosis. It acts with the masseter in raising the lower jaw.

The *pterygoideus externus* arises from the outside of the pterygoid and pterygoid plate of the sphenoid, and is inserted into the inside of the neck of the mandibular condyle, and thence forwards to the orifice of the dental foramen. In its action it is also an elevator of the mandible, since though by its direction it tends to draw the mandible somewhat backwards, it cannot do so owing to the opposition of the post-glenoid process.

The *digastric* is a large muscle which arises from the skull behind the external auditory meatus, *i.e.*, from the paroccipital. It is inserted into the inside of the anterior half of the inferior margin of the mandible.

The middle portion of the muscle is very aponeurotic internally, externally, and below. Its action is to depress the lower jaw and open the mouth (*D*).

The *stylo-hyoid* (*sty-h*) is a longish muscle which descends from the mastoid process to the side of the hyoglossus.

The *stylo-glossus* (*sty-g*) is very large. It arises from the stylo-hyal (and the ligament connecting it with the tympano-hyal), and the stylo-maxillary ligament, and thence passes to the side of the tongue.

The *stylo-pharyngeus* arises from the stylo-hyal and tympano-hyal, and passes thence to the side of the pharynx.

The *mylo-hyoid* is a flat muscle which passes from the inside of the mandible to the body of the hyoid. It unites with its fellow of the opposite side (in the middle line, beneath), the two together forming the muscular floor of the mouth.

The *genio-hyoid* is narrow, and goes from inside the mandible, near the symphysis to the basi-hyal.

The *genio-hyoglossus* is a flat, more or less triangular muscle which arises from inside the mandibular symphysis, and is inserted in a radiating manner from beneath the tongue towards its tip back to the basi-hyal.

The *hyoglossus* is also a flat muscle passing upwards from each thyro-hyal to the side of the tongue.

The *thyro-hyal* muscle is a flattened longitudinal one which unites the thyro-hyal with the chain of ossicles intervening between the tympano-hyal and basi-hyal.

The *sterno-hyoid* arises on the deep (or inner) surface of the sternum, and is inserted into the basi-hyal (*St. hy*).

The *sterno-thyroid*, arising close to the last noticed, is inserted into the thyroid cartilage of the larynx (*St. th*).

The *thyro-hyoid* is, as it were, a continuation of the sterno-thyroid, and proceeds on each side from the thyroid cartilage of the larynx to the thyro-hyal (Fig. 45, *ty*).

These three last muscles all tend, directly or indirectly, to draw back the hyoid.

The *sterno-mastoid* (Fig. 79, *St. m*) arises from the side of the manubrium (beneath the anterior part of the pectoralis major), and passing forwards and upwards is inserted into the side of the skull just above the mastoid process. If one sterno-mastoid acts alone, it tends to rotate the muzzle towards the opposite side. If both act together, they tend to depress the head as a whole, and somewhat tilt up the muzzle.

The *cleido-mastoid* arises from the clavicle, and is inserted into the mastoid process on the ventral side of the insertion of the more superficially passing sterno-mastoid.

The *scalenus secundus* lies deeply at the side of the neck. It arises from the transverse processes of the 3rd, 4th, 5th, 6th, and 7th cervical vertebræ, and is inserted into the first rib (Fig. 79, sc^2).

The *scalenus primus* (very much longer) arises mainly by strong but delicate tendons from the 4th and 5th cervical vertebræ, and is inserted into the 4th, 5th and 6th ribs near the sternum. It comes as it were out from the substance of the scalenus secundus, with which it is closely connected (sc^1).

The action of the scaleni is to pull the ribs upwards and forwards, and so to help to expand the chest.

The scaleni are entirely on the dorsal side of the axillary vessels and nerves.

The *rectus capitis anticus major* proceeds from the transverse processes of all the cervical vertebræ to the basi-occipital.

The *rectus capitis anticus minor* springs from the atlas, on its ventral aspect, and goes to the basi-occipital.

The *rectus lateralis* proceeds from the transverse process of the atlas to the paroccipital portion of the skull. It is hardly separable from the obliquus capitis superior described below (Fig. 27, 4).

The *longus colli* occupies the ventral aspect of the cervical and anterior dorsal regions. Its fibres extend between the transverse processes and bodies of the various vertebræ over which it passes, with the exception of the axis, and terminate anteriorly on the ventral surface of the atlas. It extends back to the body of the sixth dorsal vertebra.

The *rectus capitis posticus major* passes from the neural spine of the axis to the occiput.

The *rectus capitis posticus minor* goes from the neural arch to the occiput beneath the muscle last described.

The *obliquus capitis superior* extends from the transverse process of the atlas, to the paroccipital region. It is a short muscle.

The *obliquus capitis inferior* is very large. It arises from the neural spine of the axis, and is inserted into the transverse process of the atlas.

The muscle named the *splenius* is a large one arising from the whole length of the middle line of the neck, and from the anterior dorsal neural spines. It is inserted into the outer part of the lambdoidal ridge.

The *Complexus* is a very large fleshy mass arising from the sides of the last five cervical vertebræ.

It is inserted into the occipital region beneath the splenius.

Another muscle, called *Complexus tertius*, consists of a series of fleshy bundles which extend from the zygapophyses of the posterior cervical vertebræ, to the transverse process of the atlas.

The *constrictors of the pharynx* are muscles which enclose the alimentary canal in the region of the throat, and form an elongated bag of three successive muscular divisions called respectively the *inferior*, *middle*, and *superior*. They spring respectively from the sides of the larynx, the hyoidean cornua, the pterygoid bones, and the mandible, and meeting in the middle line on the dorsal side of the pharynx, are attached at their summit to the basi-occipital.

The soft palate is formed in part by the help of two pairs of small muscles; (1) the *levator palati* descends from the sphenoid, petrous and tympanic bones. Its fibres radiating, in part meet those of its fellow of the opposite side, and in part lose themselves in the side of the throat. (2.) The *circumflexus palati* arises from the skull externally to the foramen ovale, and externally to the origin of the levator palati. It then descends obliquely, and ends in a flattened tendon which passes inwards round the hamular process of the pterygoid, and expands within the velum palati.

The muscles of the pharynx and palate effect deglutition. As soon as any portion of food, or other object, is grasped by the superior muscle of the pharynx, its fibres and those of the lower pharyngeal muscles successively contract, so as to drive the substance so grasped backwards towards the stomach.

MUSCLES OF THE TRUNK AND TAIL.

§ 8. The muscles of the back are arranged in successive layers.

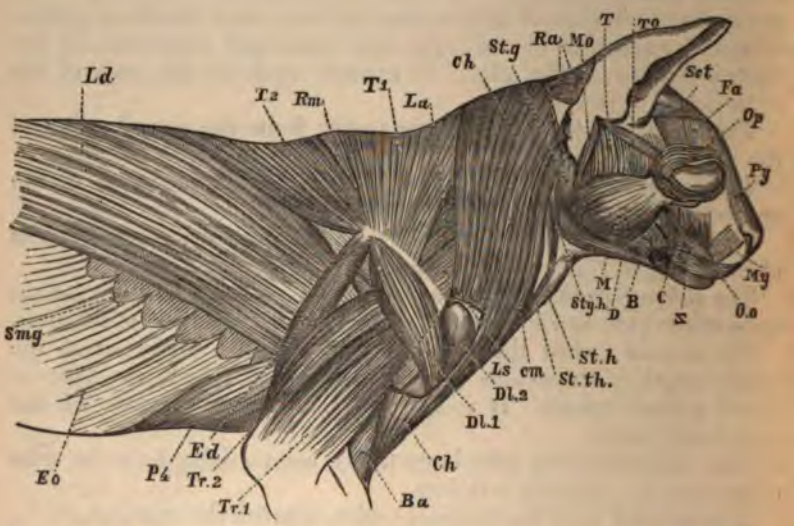


Fig. 77.—Muscles of Right Side of Fore-quarter. A rectangular cut being made in the Cephalo-humeral, to show Muscles beneath.

B. Buccinator.
Ba. Brachialis anticus.
C. Levator anguli oris.
Ch. Cephalo-humeral.
Cm. Cleido-mastoid.
D^1 and D^2. Two parts of deltoid.
D. (Of head) digastric.
Ed. External dorso-epitrochlear.
Eo. External oblique.
Fa. Fronto-auricular.
La. Levator anguli scapulæ.
Ld. Latissimus dorsi.
Ls. Levator scapulæ.
M. Masseter.
Mo. Maxillo-auricular.
My. Myrtiformis.
Oo. Orbicularis oris.
Op. Orbicularis palpebrarum.
P^4. Pectoralis.
Py. Pyramidalis.
Ra. Retrahentes auriculam.
Rc. Rhomboideus capitis.
Rm. Rhomboideus major.
Smg. Serratus magnus.
T. (Of head) temporal.
T^1 and T^2. Anterior and posterior parts of trapezius.
Tr^1, Tr^2. Parts of triceps.
To. Temporo-auricular.
Z. Zygomaticus.
Sct. Scutiform cartilage
Sty. g. Stylo-glossus.
Sty. h. Stylo-hyoid.
St. hy. Sterno-hyoid.
St. th. Sterno-thyroid.

Some of them help to retain the shoulder and pelvic girdles (and therefore also the limbs) in place.

The most superficial dorsal muscle is a cutaneous muscle—or one intimately connected with the skin. It is called the *Panniculus carnosus*, and is one of the largest muscles of the body. It forms a

fleshy sheet, which envelopes the anterior part of the back and the chest—being continued on into the neck and head as the platysma myoides already noticed. At its margin the panniculus ends in an aponeurosis, which connects it with parts adjacent. The muscular fibres converge to the axilla, being directed forwards and outwards to it on the chest, and forwards and downwards to it on the side of the back. It is inserted into the deeper fascia of the upper arm, passing in part on the inner side of the biceps muscle, and in part continuing on down to the wrist.

The muscle by its contraction effects those twitching movements of which the cat's skin is capable.

Next, beneath this cutaneous muscle is the *trapezius*, of which there are two parts, closely connected inferiorly, but dorsally, by a delicate fascia only.

A. The *hinder portion* arises from the neural spines of the dorsal vertebræ—from the second to the twelfth. It is inserted by strong fascia into the membrane which invests the external scapular muscles, the line of insertion passing obliquely across the spine of the scapula at a point situated about one-third of the length measured from its vertebral margin downwards, and dipping slightly beneath the insertion of the anterior part of the muscle (T^2).

B. The *anterior part* arises from the fascia in the middle of the neck as far forwards as the hinder end of the origin of the cephalo-humeral, with which it is connected. Its origin extends backwards till within about half an inch of the origin of the posterior part. It is inserted into the spine of the scapula, from the metacromion process upwards to the point of insertion into the scapular spine of the hinder portion of the trapezius, into the scapular spine, which insertion it slightly overlaps (T^1).

The *latissimus dorsi* is an exceedingly large sheet of muscle which takes origin from the neural spines of the vertebræ, from fifth dorsal to the fourth lumbar—its origin from the lumbar vertebræ being by fascia only. It is overlapped for almost the anterior half of its origin by the posterior part of the trapezius (*Ld*).

Its fibres converge to a tendon which, after blending with that of the teres major, is inserted into the inner side of the shaft of the humerus below the lesser tuberosity. Virtually at its anterior end it blends with adjacent fibres of the fourth part of the pectoralis, and is then inserted into fascia in the neighbourhood of the axilla. Before its insertion it gives off a muscle—the *inner dorso-epitrochlear*—which descends, and blending with the smaller external dorso-epitrochlear is inserted into fascia on the inner side of the olecranon. Its action is to pull the arm backwards, or, if the arm be fixed, to bring the body forwards. It thus gives much aid in climbing (Fig. 81, *ide*).

The *external dorso-epitrochlear*.—This is a slender muscle (Fig. 77, *ed*), which takes origin from fascia outside the spine of the

scapula, between the hindermost and uppermost part of the deltoid, and the posterior end of the insertion of the trapezius. Blending with the internal dorso-epitrochlear, it is inserted as above stated.

The *serratus posticus anterior* arises by fascia from the mid-line of the back, and is inserted by very thin and faintly marked muscular digitations, into the outer surfaces of the ribs, from the second to the twelfth—the digitations inclining downwards and very much backwards. Posteriorly it is over-lapped by the next muscle to be noticed.

The *serratus posticus posterior* arises from the fascia of the middle of the back, and is inserted by six digitations into the outside of the eighth, ninth, tenth, eleventh, and twelfth ribs. The digitations are inclined downwards and very slightly forwards. Anteriorly it overlaps the hinder part of the serratus posticus anterior.

A membrane called the "vertebral aponeurosis," is continuous with the serratus posticus posterior, and passing forwards between the muscles of the shoulder and those of the trunk, it also binds down the great muscle to be next described.

Erector spinæ.—Under this title is included a very large and complex muscular mass occupying the groove which exists on each side of the dorsum of the skeleton, between the neural spines and the ribs at the point where the latter are much arched upwards. It is divided into two parts, one being nearer to, the other farther from the neural spines. Each of these two parts extends forwards towards the neck from the common origin of both in the sacral region.

Sacro-lumbalis.—This name designates that part of the erector spinæ which is the more externally placed, and is attached to the ribs. It is a very thick muscle at its origin from the ilium and sacrum close to their line of junction. It is inserted into the lumbar transverse processes on their dorsal aspect and, by tendons, into all the ribs at their angles—the tendons becoming longer as the muscle advances forwards. The last portion, that inserted into the transverse process of the seventh cervical vertebra, is the representative of a muscle called the *cervicalis ascendens.*

Longissimus dorsi is the term applied to the inner part of the erector spinæ. It is much smaller posteriorly than the last described, but extends further forwards. It arises from the anterior margin of the ilium, and the fascia investing the erector spinæ dorsally, and is inserted into the dorsal surface of the lumbar transverse processes, the metapophyses and the ribs on the dorsal side of their angles.

The *transversalis cervicis* is the continuation of the last described muscle into the neck, where it is invested by firm, strong tendons into the transverse processes of the five last cervical vertebræ.

The *spinalis dorsi* is really but an inner portion of the longissimus dorsi, and goes from the neural spines of the more posterior to those of the more anterior dorsal vertebræ. As continued on to the spine of the axis, it is called the *spinalis colli.*

Other minor divisions of the erector spinæ bear the names *semi-spinalis, multifidus spinæ, rotatores spinæ, inter-spinales,* and *inter-transversales,* and have their fibres directed as follows: at first, from the transverse processes to the neural spines; the second, from metapophyses (or the parts which serially correspond with the met-

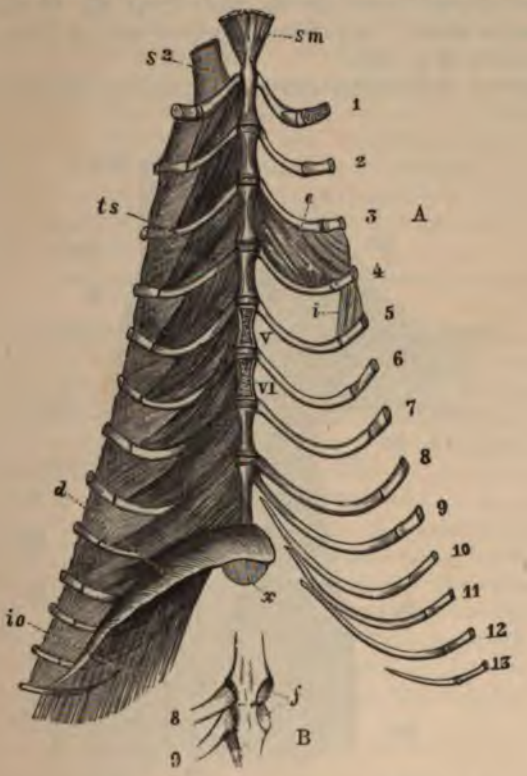


Fig. 78

A.—INTERNAL ASPECT OF STERNUM AND COSTAL CARTILAGES—MUSCLES OF LEFT SIDE BEING ALMOST ALL REMOVED.

No. 1 to 13. The ribs.
V, VI. The fifth and sixth sternebræ.
d. Diaphragm.
e. Internal intercostals.
i. External intercostals.
io. Internal oblique.
sm. Sterno-mastoid.
s². Scalenus secundus.
ts. Triangularis sterni.
x. Xiphoid cartilage.
The small figure below represents on one side the sternal ends of the cartilages of the eighth and ninth ribs, and on the other side the sockets (*f*) for the cartilages of the eighth and ninth of the other side.

B.—ARTICULATIONS OF CERTAIN COSTAL CARTILAGES AND STERNUM.

apophyses,) to neural laminæ in front of them; the third, from the transverse processes to the neural laminæ next in front of them; the fourth, from neural spine to neural spine, and the fifth and last, from one transverse process to another.

If these various muscles of both sides of the body act, they flex the spine vertically—as when the animal bounds along. If those of

one side act alone, the whole backbone is flexed towards the side of such action.

The *levatores costarum* are small groups of fibres passing obliquely backwards from the dorsal transverse processes to the respective ribs at their proximal parts.

Layers of fibres extending obliquely from rib to rib are called "intercostal muscles," and there are two sets of them, one inner, the other outer (Fig. 78).

The *external intercostals* are more dorsally situated, since each

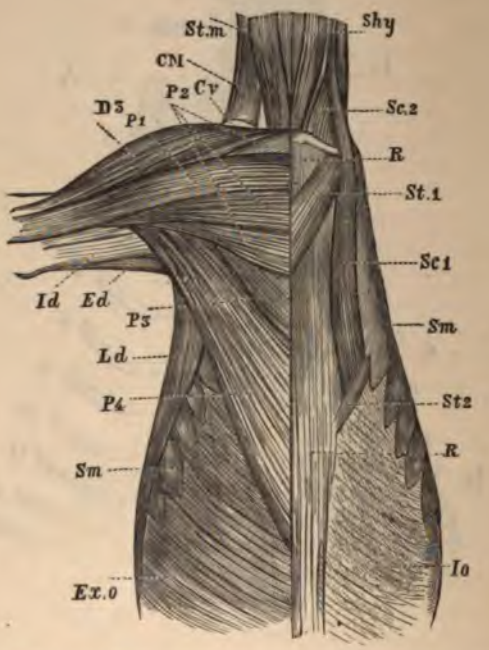


Fig. 79.—Muscles of Ventral Surface of Trunk—the left Fore-limb and left Pectoral Muscles being removed.

CM. Cleido-mastoid.
Cv. Clavicle.
D³. Deltoid.
Ed. External dorso-epitrochlear.
Exo. External oblique.
Id. Internal dorso-epitrochlear.
Io. Internal oblique.
Ld. Latissimus dorsi.
P¹, *P²*, and *P³*. Pectoralis.
R. Rectus abdominis.
Sc¹. Scalenus primus.
Sc². Scalenus secundus.
Shy. Sterno-hyoid.
Sm. Serratus magnus.
St¹. Sternalis.
St². Second sternalis.
St. m. Sterno-mastoid.

such intercostal connects two ribs, all the way from their tubercles to their cartilages. Their fibres are directed backwards and downwards (*i*).

The *internal intercostals* have their fibres directed backwards and upwards, and the sheet of such fibres which connects each pair of ribs reaches from the sternum upwards as far as the angles of the

ribs. The intercostal nerves and vessels are interposed between the two sets of intercostal muscles (*e*).

The *triangularis sterni* is the name given to a layer of muscle which diverges forwards to the cartilages of the ribs from the deep (inner) surface of the sternum (Fig. 78, *ts*).

The *diaphragm* is (as has been before mentioned) a very important partly fibrous, partly muscular structure, which separates the thoracic and abdominal cavities. It forms a partition convex forwards and concave backwards, and is attached to the xiphoid cartilage, to several ribs, to the centra of the lumbar vertebræ, and to the aponeurosis, which invests the quadratus lumborum and psoas muscles.* At its circumference the diaphragm is muscular; its central portion is tendinous. It is perforated for the passage of certain organs—namely, for the œsophagus and for two great blood-vessels called aorta and inferior vena cava.

The muscles just enumerated aid the process of respiration as follows:—

Apart from the elasticity of the substance of the lungs, respiration is effected by the successive enlargement and contraction of the thoracic cavity. We have seen that the ribs are movably articulated to the vertebral column. They can be drawn forwards (and the cavity of the thorax can be in consequence enlarged) by the external intercostals and levatores costarum, but the main agent in this process is the contraction of the muscular fibres of the diaphragm resulting in a diminution of its convexity. Air rushes in to fill the thus enlarging cavity, and we thus have *Inspiration*. Expiration is effected by the drawing backwards of the ribs by the internal intercostals and by the relaxation of the contraction of the fibres of the diaphragm, which in consequence resumes its more convex shape, and so contracts the thoracic cavity, a process further aided by the contraction of the muscles of the belly, the external and internal oblique, the rectus and transversalis.

The *abdominal region* of the body is invested by three great sheets of muscle and membrane, which enclose and support the abdominal viscera—and tend by their contraction to expel the contents of such viscera and, as just said, indirectly to aid in respiration.

The first of these muscles, the *external oblique*, arises by eight digitations from the eight hindmost ribs and from the lumbar fascia. Its fibres pass obliquely downwards, backwards and inwards (towards the mid-ventral line,) to be inserted by muscle and membrane into the brim of the pelvis—part of the membrane (or aponeurosis,) divides into the "external" and "internal" tendons. Between these tendons (of which the internal is the stronger,) an aperture is left called the "external abdominal ring," (through which certain structures pass,) bounded in front by what is called Poupart's ligament.

This so-called "ligament" is really but a band of delicate fascia,

* These are described amongst the muscles of the hind limb.

which extends from the pubic symphysis to the anterior part of the ventral margin of the ilium.

In front of the pelvis the muscle ends in aponeurosis, which meets that of its fellow of the opposite side in the mid-ventral common fascia, which extends forwards to about the fourth rib. It passes superficially to the rectus muscle, but its fascia is closely adherent to the surface of the rectus.

The deeper abdominal muscle, the *internal oblique*, is another sheet partly muscular, partly membranous, but its fibres are directed downwards, forwards and inwards. It arises from the lumbar fascia—on the outer side of the erector spinæ—from the entire ventral margin of the ilium and from the pubis. At its origin it leaves three apertures at the brim of the pelvis. Through the uppermost of these the psoas muscle passes out to the thigh. The next below is traversed by the great vessels, and through the lowest the spermatic cord makes its exit in the male. It is inserted inside the cartilages of the ribs, and, behind the thorax, joins with its fellow of the opposite side—its fascia passing on the ventral side of the rectus to about the middle of the abdomen, in front of which point it passes above the rectus.

The deepest of the abdominal muscles, the *transversalis*, arises from the cartilages of the ribs behind the diaphragm, from the ventral margin of the ilium and from the fascia which invests the under side of the erector spinæ. It is therefore separated at its origin by a wide interval from the origin of the internal oblique; the interval being occupied by the erector spinæ and by fat. The muscular fibres of the transversalis extend vertically downwards (*i.e.*, transversely to the long axis of the body,) to the margin of the rectus, within which its fascia extends—*i.e.*, on the dorsal surface of the rectus. The abdominal nerves extend round the body between this muscle and the internal oblique.

Rectus abdominis.—This is a long muscle which, arising from the symphysis pubis, runs forwards in contact with its fellow of the opposite side, to be inserted into the third rib, and thence on, by aponeurosis, to the second and first ribs. It is enclosed ventrally by the aponeuroses of the external and internal oblique from its origin to the middle of the abdomen. Thence forwards it is enclosed below by the aponeurosis of the external oblique, while above, it is invested by the aponeuroses of the internal oblique and transversalis (Fig. 79, *R*).

The rectus is separated from its fellow of the opposite side by a narrow interval, which is occupied by a tendinous cord—the *linea alba*.

The fibres of the rectus are interrupted at intervals by very faint marked transverse tendinous intersections.

Sternalis.—This small muscle (St^1) arises from the anterior end of the rectus abdominis close to the sternum, at the third and fourth costal cartilages. It passes forwards and outwards, and is inserted into the first rib just ventrally to the insertion of the scalenus primus. A small second sternalis (St^2) extends from the outer border

the rectus, and passes outwards to be inserted between the fifth and the sixth hindmost digitations of the serratus magnus, just behind the hinder end of the scalenus primus.

External to the abdominal muscles the trunk is invested by an aponeurosis called the *superficial fascia*. At its posterior part this fascia is separable into two layers, the deeper of which adheres to Poupart's ligament, while the more superficial is (in the male) prolonged into the scrotum—surrounding the structures which pass from out the abdominal ring into that receptacle.

Internal to the abdominal muscles, the abdomen is lined by a membrane called the *fascia transversalis*. It is pierced near its hinder margin by an opening called the *internal abdominal ring*, through which the spermatic cord passes in the male.

Levator caudæ externus.—This is the continuation backwards of the longissimus dorsi, and arises from the lumbar and sacral transverse processes, and is inserted by a succession of long, delicate tendons into the metapophysial parts of the caudal vertebræ successively. This and the following muscle bend the tail upwards.

The *levator caudæ internus*.—This is the continuation backwards of the semi-spinalis, and is a yet more medianly-placed dorsal muscle. It is formed of a number of delicate, fleshy bellies and tendons, which connect the dorsal and lateral regions of successive caudal vertebræ.

The *pubo-coccygeus* is a thin, flat muscle which arises from inside the pubis and goes to the ventral aspect of the third, fourth, and fifth caudal vertebræ.

The *ilio-coccygeus* passes from the inner side of the ilium to the ventral surfaces of the fourth, fifth, sixth, and seventh caudal vertebræ.

The *sacro-coccygeus* arises (on each side) from the lateral part of the ventral surface of the sacrum, and from the sides of the ventral surface of the first eleven caudal vertebræ. It sends its tendons forth back along the ventral surface and side of the tail to its extremity.

The *infra-coccygeus* is situated in the mid-ventral line of the tail, thus connecting together its successive vertebræ.

The above four muscles bend the tail downwards.

The *ischio-coccygeus* is large and thick. It springs from the spine and internal surface of the ischium, and is inserted into the whole length of the transverse processes of the first four caudal vertebræ.

Inter-transversarii caudæ are small slips connecting laterally the successive caudal vertebræ. It takes origin from the transverse processes of the last sacral vertebra.

This and the preceding muscle flex the tail laterally.

The following muscles are found in the vicinity of the root of the tail, and are some of them connected therewith:—

Levator scroti.—This is a cutaneous muscle which arises in the dorsum of the tail at about the fifth caudal vertebra, and becoming connected with the *sphincter ani externus* expands upon the scrotum

(or upon the parts analogous in the female) as a delicate layer of cutaneous muscular fibres.

The *ischio-cavernosus* is a small muscle arising from inside of the ischium a little below its tuberosity and ending in a tendinous expansion applied to a part hereafter to be described as the corpus cavernosum (Fig. 115).

The *caudo-cavernosus* is a slender muscle which passes backwards from the under-surface of the root of the tail to the corpus cavernosum between Cowper's glands.

Transversus perenæi.—This is a small but very distinct muscle which arises from the inner side of the ischium below its tuberosity. It joins its fellow of the opposite side in front of the anal aperture, being more or less united with the sphincter ani internus.

The *compressor urethræ* is a muscle which springs from the inner side of the pubis, and divides into two portions, one passing above and in front of, and the other below and behind, the urethra. These portions end by meeting with corresponding divisions of the muscle of the opposite side of the pelvis. It is very large in the male, extending between the prostate and Cowper's glands.

The *ano-coccygeus* arises (in the middle line) from beneath the second and third caudal vertebræ, and passes downwards and backwards, expanding as it goes, to the upper part of the rectum.

The *recto-coccygeus* arises from the upper lateral part of the rectum. It ascends, and, joining with its fellow of the opposite side, passes upwards and backwards between the two ano-coccygeus muscles to the under surfaces of the sixth and seventh caudal vertebræ. It is covered laterally by ilio-coccygeus and pubo-coccygeus.

The *sphincter ani externus* surrounds the root of the tail, the anus, the anal pouches, and the external generative organs. It arises from the dorsum of the tail at about the fifth caudal vertebra. The anal pouches are two rounded sacs, each about as big as a pea, placed one on each side of the rectum close to the anus.

The *sphincter ani internus* is a mass of fibres arranged circularly around the anus in front of the sphincter externus and more or less united with it, especially with the fibres which constrict the anal pouches.

Thus just as the anterior end of the alimentary tube is surrounded by a sphincter muscle—the orbicularis oris—so is its posterior termination also surrounded by an analogous muscular constriction—the sphincter ani.

This muscle is a more complete sphincter than its anterior analogue, since it is not (as that is) interrupted by any median notch. It is connected beneath with the transversus perenæi muscles at their median junction. Above, it is connected by a tendon with the caudal vertebræ at the root of the tail.

A *retractor penis* muscle passes from the ventral aspect of the hinder end of the rectum, to the ventral surface of the penis towards its distal end.

MUSCLES OF THE LIMBS.

THE FORE-LIMB.

§ 9. *Serratus magnus.*—This is a large sheet of muscle which arises by ten digitations (the anterior four being wider than the others) from the sternal aspect of the first ten ribs. It is inserted into the vertebral margin of the scapula. The scaleni muscles dip in between the second and third, and between the fourth and fifth digitations of this muscle.

The *levator anguli scapulæ* is a second sheet of muscle similar to the preceding, and so closely connected with it that they can only be separated artificially. It is inserted into the scapula with the serratus magnus. It arises from the transverse processes of the last five cervical vertebræ. The combined insertion of this and the serratus extends along the whole vertebral margin of the scapula posteriorly from a point just in front of the insertion of the rhomboideus capitis.

The combined action of these two muscles is to suspend the body as in a hammock from the summits of the two fore-limbs. It aids also in any pushing action of the fore-limbs, and therefore in springing.

The *cleido-mastoid* has been already described.*

The *rhomboideus major* is a sheet of muscle which takes origin (beneath the trapezius) from the neural spines of the six hinder cervical and the four or five most anterior dorsal vertebræ. It is inserted into the vertebral margin of the scapula; its insertion extending forwards about half an inch in front of the vertebral end of the spine of the scapula.

The *rhomboideus capitis* is a long, narrow muscle which arises from the lambdoidal ridge, and is inserted into the vertebral margin of the scapula, just in front of the insertion of the rhomboideus major, dipping in between the insertion of the last-named and that of the serratus magnus.

Pectoralis.—This is a very large muscle which consists of five portions, all going from the sternum and sternal ends of the costal cartilages to the upper arm. No part goes to the coracoid.

(1.) The most superficial part (Fig. 79, p^1) is a long, rather narrow, band of parallel fibres which *arises* from beneath the manubrium and attachment of the first two costal cartilages. It is inserted partly into the fascia of the flexor surface of the fore-arm, but partly joins the cephalo-humeral and is inserted with it.

(2.) The second and largest part (p^2) *arises* from the manubrium and sternum as far back as the fourth costal cartilage. It also arises from fascia just in front of the manubrium. It is inserted into the outer side of the deltoid ridge of the

* See *ante*, p. 134.

Fig. 80.—Dorsal (Extensor) Muscles of Fore-limb.

A m d. Abductor minimi digiti.
An. Anconeus.
B. Biceps.
B a. Brachialis anticus.
*D*¹ and *D*². Deltoid.
E c d. Extensor communis digitorum.
*E c*¹. Extensor carpi radialis longior.
*E c*². Extensor carpi radialis brevior.
E i. Extensor indicis.
*E m d*¹, *E m d*², and *E m d*³. Extensor minimi digiti.
E o p. Extensor ossis metacarpi pollicis.
F c u. Flexor carpi ulnaris.
*F p d*⁵. Flexor profundus digitorum.
I s. Infra-spinatus.
*P*³. Pectoralis.
S l. Supinator longus.
S sp. Supra-spinatus.
T ma. Teres major.
T mi. Teres minor.
*Tr*¹, ², and ⁴. Triceps

Fig. 81.—Ventral (Flexor) Muscles o Fore-limb.

B. Biceps.
B a. Brachialis anticus.
C b. Coraco-brachialis.
C h. Cephalo-humeral.
*E c*¹. Extensor carpi radialis longior.
*E c*². Extensor carpi radialis brevior.
*F p d*⁵. Flexor profundus digitorum.
F r. Flexor carpi radialis.
*F s. d*¹ and ². Flexor sublimis digitorum.
*F u*¹ and ². Flexor carpi ulnaris.
I d. Internal dorso-epitrochlear.
L d. Latissimus dorsi.
*P*³ and *P*⁴. Pectoralis.
P l. Palmaris longus.
T p l. Tension of palmaris longus, cut shor show the subjacent flexor tendons.
P t. Pronator teres.
S s. Sub-scapularis.
S sp. Supra-spinatus.
T ma. Teres major.
*Tr*²⁻³. Triceps.

humerus, and extends down (between the biceps and brachialis anticus to the summit of the lowest third of the humerus. It is imperfectly divisible into two layers. The more superficial of these (p^2 A) arises from the more anterior part of the sternum, and goes to the lower part of the insertion, while the other part (p^2 B) both arises and is inserted for the whole length of the origin and insertion of the second part.

3.) The third part (p^3) *arises* from the sternum between the second and sixth costal cartilages. It is *inserted* into the head of the humerus between the tuberosities by strong fascia closely connected with that of the supra-spinatus muscle. It is also inserted by muscular fibres for a short distance into the front of the humerus just below the great tuberosity.

4.) The fourth part is the most posterior in origin. It is long and narrow, and its fibres run more antero-posteriorly than do the others. It *arises* from the sternum between the fifth costal cartilage and the root of the xiphoid. Towards its insertion it blends with the ventral part of the latissimus dorsi, and some of its fibres are inserted into the fascia in the neighbourhood of the axilla. Its main *insertion* is (by strong fascia) into the inner side of the deltoid ridge of the humerus below, and on the inner side of the insertion of the third part.

5.) The fifth, and much the smallest part, is the most anterior (p^5). It arises from the side of the manubrium, covered by, and more or less blended with, the second part of the pectoralis. It passes outwards, becoming slightly connected with the clavicle, and is inserted into the humerus just above the insertion of the second part. It may be called the subclavicualr part of the pectoralis.

This muscle adducts the humerus, and enables the cat to give a verful blow with the paw inwards. If the arm be fixed, it then ds to draw the body forwards or, in climbing, upwards.

The *cephalo-humeral* is a large muscle which arises conterminously, l more or less blended with the anterior part of the trapezius. main part takes origin from the back of the skull and the lambdal ridge, and from fascia in the middle of the neck (Fig. 77, *Ch*). It passes down outside the clavicle (with which it contracts a ght adhesion) and outside the biceps—covering the front of the per arm. Near the elbow-joint it fuses with the brachialis icus (passing to the outer side and front of the biceps), and is erted into the coronoid process of the ulna, having first received addition from the first part of the pectoralis.

The third part of the deltoid fuses anteriorly with the cephalomeral.

The *deltoid* consists of three portions:—(Fig. 80, D^2) a part which ises from the scapula between, and from, the acromion and metromion processes; and (D^1) a part which arises from the hinder side f the scapular spine, conterminous with the insertion of the anterior art of the trapezius.

These two parts have a common insertion into the lower third of the flat deltoidal surface on the outer side of the humerus—external to the bicipital groove.

The third part arises from the hinder side of the clavicle and fuses with the adjacent part of the cephalo-humeral.

The *levator claviculæ* is a muscle which takes origin from the transverse process of the atlas.

It is inserted into the end of the metacromion (between the first and second parts of the deltoid), being overlapped by the cephalo-humeral and, quite anteriorly, by the sterno-mastoid.

The *supra-spinatus* forms a very large muscular mass, which projects much beyond the anterior margin of the scapula. It arises from, and occupies the supra-spinous fossa of the scapula, with anterior side of the spine and acromion. It is inserted into the upper margin of the great tuberosity.

The *infra-spinatus* occupies the infra-spinous fossa of the scapula (arising from its whole surface, including the hinder side of the scapular spine, acromion and metacromion), and is inserted into the concavity on the posterior part of the outer side of the great tuberosity.

The *teres minor* arises from the lower half of the axillary margin of the scapula, and is inserted into the hinder margin of the great tuberosity, below the insertion of the infra-spinatus.

The *teres major* is a much larger muscle which takes origin from the posterior angle of the scapula and the upper third of its axillary margin. It is inserted below the lesser tuberosity by a strong tendon common to it and to the latissimus dorsi.

The *subscapularis* occupies the whole inner surface of the scapula. Its fibres converge from this extensor origin and are inserted into the lesser tuberosity and capsular ligament of the head of the humerus.

The supra-spinatus, infra-spinatus and teres minor rotate the limb outwards, or tend to draw it forwards and raise it.

The subscapularis and teres major rotate the limb inwards, and tend to draw it backwards.

The *coraco-brachialis* is a very short muscle which arises by a delicate tendon from the coracoid process of the scapula, and is inserted into the inner side of the humerus just below the insertion of the subscapularis (and mainly above that of the teres major), between the biceps and the fourth head of the triceps (Fig. 81, *Cb*).

The *biceps* arises by a tendon which takes origin from the upper margin of the glenoid cavity of the scapula. Passing down it is inserted by a tendon into the tubercle of the radius (*B*).

The *brachialis anticus* is a muscle placed on the outer side of the front aspect of the humerus, taking origin from the surface of that bone as high up as just below the insertion of the teres minor (Fig. 80, *Ba*).

It passes down between the second part of the pectoralis major, the triceps and the supinator longus, and is inserted into the coronoid process of the ulna, and into the ulna on the inner side of that

ocess. At its upper part this muscle is closely connected with the ndon of insertion of the deltoid.

The coraco-brachialis draws the arm a little forwards and upwards, e biceps and brachialis anticus flex the elbow-joint, which is tended by the following muscle.

The *triceps*.—This is an enormous muscle, consisting of five parts.

(1.) The first part (Fig 80, Tr^1), takes origin from the summit of the outer, posterior part of the humerus, within the tendon of insertion of the teres minor. Passing downwards, it blends with the second part a little above the elbow.

(2.) The second and largest part arises by a strong, broad tendon from the lower half of the axillary border of the scapula, between the subscapularis and teres minor; after receiving the accession of the first part it is inserted by a strong tendon into the end of the olecranon.

(3.) The third part takes origin from the upper part of the inner side of the shaft of the humerus, mainly below, but partly overlapped by, the tendon common to the teres major and latissimus dorsi. Passing downwards it soon blends with the fourth part.

(4.) The fourth part takes origin from the whole upper surface of the humerus just below its head,—from the origin of the first part of the triceps externally, to the insertion of the coraco-brachialis internally. Passing downwards it receives the accession of the third part and is inserted into the olecranon.

(5.) The fifth and much smallest part arises from just above the internal condyloid foramen, and from the bridge of bone bounding that foramen, down to the internal condyle. Passing obliquely backwards (Fig. 81, t^5) it is inserted into the inner margin of the olecranon.

The *anconeus* is much larger than the fifth head of the triceps. arises from a triangular surface (with the apex upwards,) on the wer half of the shaft of the humerus (especially towards the outer le of that bone,) its origin extending to the margins of the cranal fossa and right down to the external condyle. The scle lies between the first and third parts of the triceps, and is serted into the whole of the fossa on the outside of the olecranon.

The *muscles of the fore-arm* consist of pronators and supinators, xors and extensors, and their names sufficiently indicate their actions.

The *pronator teres* arises from the inner condyle and passes down liquely to its insertion into about the middle third of the front of e radius.

The *flexor carpi radialis* is long and narrow. It arises from the ternal condyle of the humerus in common with the head of the xor profundus, and is inserted into the proximal end of the lmar surface of the second metacarpal.

The *palmaris longus* arises from the internal condyle, and passing wn becomes tendinous at the wrist, and ends in an aponeurotic xpansion (called the *palmar fascia*), which exhibits tendinous

thickenings, and finally invests the bases of the digits. Near the wrist it gives origin to the ulnar part of the flexor sublimis.

Flexor sublimis digitorum or perforatus.—This muscle consists of two distinct parts, each of which is inseparably connected with another muscle.

The ulnar part of the flexor sublimis arises from the ulnar side of the palmaris longus close to the wrist. It ends in two tendons, which go to the fourth and fifth digits respectively (Fig. 81, *Fsd*[1]).

Its radial part arises from the surface of the ulnar part of the flexor profundus—from the upper part of its tendon. It divides into two small fleshy portions, the larger of which gives origin to two delicate tendons which go to the index and third digits (*Fsd*[2]).

All these four tendons go to the second phalanx of their respective digits, each splitting (before its insertion) to allow a tendon of the deep flexor (next to be described) to pass through, whence this flexor receives its second above-given denomination.

The second portion of the radial part of the muscle ends in a very delicate tendon, which goes to the ulnar side of the pollex.

The flexor profundus digitorum or flexor perforans.—This is a very complex muscle, which arises by five heads.

(1.) The first of these arises from the internal condyle of the humerus, in common with the third head and with the humeral head of the flexor ulnaris. Passing down it ends in a tendon which gives off superficially the radial part of the flexor sublimis, while on its deep surface it receives the insertion of the muscular fibres of the second part. Its tendon fuses with the main tendon at the wrist.

(2.) The second part, which is large and fleshy, arises from the outer surface of the ulna—from near the wrist nearly to the end of the olecranon, and passing up at the olecranon inside both the flexor carpi ulnaris and the fifth part of the triceps. It is inserted into the deep surface of the tendons of the first part of the flexor profundus.

(3.) The third part arises from the internal condyle, in common with the first part, and is also connected with the fourth part some little distance below its origin. It ends in a rather delicate tendon, which joins the main tendon at the wrist.

(4.) The fourth part arises from the internal condyle, in common with the flexor carpi radialis. It becomes connected with the third part, and further down, ends in a rather strong tendon which joins the main tendon at the same time as does that of the third part.

(5.) The fifth part arises from the flexor surface of the radius between the supinator brevis and pronator quadratus, and is inserted into the common tendon (Fig. 81, *Fpd*[5]).

The common tendon divides into five small tendons, which go to the distal phalanges of the five digits. Each of these tendons, except that to the pollex, passes through the split before mentioned as existing in each corresponding tendon of the flexor sublimis. It

is on this account that the flexor profundus is also called the "perforans."

The *lumbricales* are small, worm-like muscles (whence their name), which arise from the palmar surface of the deep flexor tendons of the four outer digits, and are inserted into the sheaths of the extensor tendons on the dorsal aspect of the digits as follows:—

One arises from the radial side of the tendon going to the index and is inserted into the radial side of the index. Another springs from the palmar surface of the tendon of the medius, and goes to the radial side of the medius; the third springs from the palmar surface of the tendons of the third and fourth digits, and goes to the radial side of the fourth digit. The fourth and last arises from the radial side of the tendon going to the fifth digit, and is implanted also into the radial side of the fifth digit.

The *flexor carpi ulnaris* arises by two heads (separated by the ulnar nerve), one from the inner condyle of the humerus, the other from the inner side of the olecranon, almost to its very extremity, so that it dips in under cover of the fifth part of the triceps. The humeral belly of this muscle is intimately connected with that head of the flexor profundus which gives origin to a part of the flexor sublimis. The two heads continue separate a considerable distance, and then unite and are inserted into the pisiforme and the fifth metacarpal.

Pronator quadratus.—The fibres of this muscle extend obliquely downwards from the ulna to the radius, on the deep flexor surfaces of those bones for rather less than the lower half of each.

Supinator longus.—This is a long and very slender muscle, which arises high up, very much above the external condyle, from the outer surface of the brachialis anticus, and from the middle third of the outer surface of the humerus. It is inserted into the outer side of the distal part of the radius (Fig. 81, *Sl*).

The *extensor carpi radialis longior* is also a long narrow muscle, which arises from the supinator ridge below the origin of the muscle last described, and is inserted into the dorsum of the second metacarpal.

The *extensor carpi radialis brevior* arises close beside and closely connected with the last. Also long and narrow, it ends in a tendon, which is implanted into the dorsum of the third metacarpal.

Extensor communis digitorum.—This muscle takes origin from the external condyle of the humerus, and is more or less divisible into two parts. One part sends tendons to the second and third (or second, third, and fourth) digits, and the other to the fourth and fifth digits. Its tendons are inserted into the second and third phalanges of each of the four ulnar digits.

The *extensor minimi digiti* is of about the same size as the last described muscle, arising in common with it and running down beside it. It soon divides into three parts, whereof the first and second are much more closely united together than they are to the third part. The first two parts arise in front of and somewhat

within the third part, and at about the middle of the arm divide into two tendons. The more radial of these goes to the fourth digit, and the more external (the paw being prone) to the third digit. The third part arises highest up and superficially to the other parts. It ends in a tendon which runs deeply and (passing at the wrist through a separate synovial sheath) goes to the fifth digit (Fig. 80).

The *extensor indicis et extensor secundi internodii pollicis* is a very long and slender muscle, which springs from the outer margin of the ulna, for almost its whole length, and from the outside of the olecranon, being there covered in by the anconeus. It ends in two delicate tendons, which go to the pollex and index digits respectively.

The *extensor ossis metacarpi pollicis* is a large muscle arising from a great part of the extensor surface of both the radius and the ulna, and from the interosseous ligament. It is inserted into the first metacarpal. Its origin on the ulna extends almost up to the olecranon. On the radius it is conterminous with the insertion of the supinator brevis.

The *extensor carpi ulnaris* takes origin from the external condyle of the humerus (below the other muscles there arising), and is inserted, by a very strong tendon, into the fifth metacarpal.

The *supinator brevis* is a rather deeply placed muscle, which comes from the outer condyle of the humerus and the upper part of the ulna, and is inserted into the radius, wrapping it round somewhat from behind.

The *muscles of the fore-paw* are numerous but small. The pollex (which has no perforated flexor) is provided with a *flexor brevis*, which extends from the trapezium, the trapezoides, and adjacent deep palmar fascia, to be inserted into the base of the proximal phalanx of the pollex.

Opponens pollicis.—This is a very small muscle, closely connected with the last-named. Similar in origin, it is inserted into the metacarpal of the pollex.

An *abductor brevis pollicis* passes from the trapezium and annular ligament of the wrist to the proximal phalanx of the pollex.

A *flexor brevis minimi digiti* arises from the annular ligament and unciforme, and is inserted into base of the first phalanx of the fifth digit.

A few fibres with a similar origin, but inserted into the fifth metacarpal, constitute an *opponens minimi digiti.*

The *adductor minimi digiti* is a relatively considerable muscle, which arises from the palmar fascia at the root of the pollex, and is inserted into the first phalanx of the fifth digit.

An *abductor minimi digiti* arises from the outer side of the pisiforme, and is inserted by a long and delicate tendon into the ulnar side of the proximal phalanx of the fifth digit (Fig. 80, *Amd*).

The *interossei* are small muscles which arise from the sides of the metacarpals and go to the sides of the proximal phalanges. When the back of the paw is looked at (the other muscles being dissected off) four interossei, called *dorsal*, are to be seen as follows: one on each side of the third digit, one on the radial side of the index, and

one on the ulnar side of the fourth digit. When the palmar surface of the paw is looked at, a double interosseus is to be seen on the ulnar side of the index; one is also to be seen on the radial side of the fifth digit, and we also see those which were partly visible when the paw was viewed dorsally. We thus learn that those seen dorsally on either side of the third digit have a common belly on the palmar surface, as also that the dorsal interosseus, which appears on the ulnar side of the fourth digit, has a palmar division going to the radial side of the fourth digit. In this way each digit (apart from the pollex) has a pair of interossei, except the fifth digit, which only has an interosseus muscle on its radial side.

These little muscles act mainly as short flexors, but also somewhat as extensors. Each is a double-bellied muscle which divides, and is doubly inserted: one insertion being into the first phalanx and sesamoid beneath it, and the other extending upwards towards the sheath of the extensor tendons, and so helping to retract the claws.

The muscles of the anterior region of the trunk, and of the fore-limbs, are invested by a membrane called the *superficial fascia*, and a synovial membrane is placed in the subcutaneous tissue which invests the acromion, olecranon, and joints of the paw.

A deeper, stronger fascia is placed in the axilla, which descends the arm and becomes continuous with the annular ligaments of the wrist, beneath which pass the flexor and extensor tendons, their passage being facilitated by the presence of synovial membranes.

The strong palmar fascia, in which the palmaris longus ends, has already been mentioned.

As to the STRETCH OF MUSCLES over the segments of the pectoral limb, we have seen that some muscles which are inserted into the shoulder-girdle proceed from the trunk, as the trapezius; others proceed from the shoulder-girdle to the upper arm, as the deltoid; others from the upper-arm to the fore-arm, as the brachialis anticus; and, finally, others from the fore-arm to the hand, as the deep flexors of the digits. But there are also muscles which pass direct from the trunk to the upper-arm, as the latissimus dorsi; or direct from the shoulder to the fore-arm, as the biceps; or direct from the upper-arm to the hand, as do a great number of the muscles inserted into the latter—the flexores carpi radialis and ulnaris and the flexor sublimis digitorum, arising, as we have seen, from the inner, or ulnar, condyle of the humerus; and the extensores carpi radialis longior et brevior, the extensor communis digitorum and extensor carpi ulnaris, arising, on the contrary, from its outer, or radial, condyle. The extensors, as well as the flexors of the digits, all take origin in the arm and not in the hand itself.

As to the DIRECTION of the muscles of the arm the long flexors of the pollex and other digits are not oblique, but arise on the same side of the limb as that on which they are distributed.

The extensors of the outer digits cross the extensors of the thumb.

As to the NUMBER OF MUSCLES WHICH MAY BE INSERTED INTO A SINGLE DIGIT, we see that the ideal perfection of having both a flexor

and an extensor inserted into every segment from the metacarpal to the last phalanx is only attained in the index and the digitus minimus.

Thus in these digits the metacarpal bones are flexed by the flexor carpi radialis and flexor carpi ulnaris respectively, while no other metacarpal has a separate flexor. They are extended by the extensores carpi radialis longior and ulnaris respectively. The first phalanx of each is flexed by the interossei, and extended by the extensores indicis and minimi digiti respectively. The second phalanx of each is flexed by the flexor perforatus and extended by the extensor communis digitorum. The ultimate phalanx in each is flexed by the flexor perforans and extended by subdivisions of the interossei (aided by the lumbricales), which join the extensor sheath and are finally inserted into the distal phalanx

Fig. 82.—Superficial Muscles of Thigh.

B. Biceps femoris.
G. Gastrocnemius.
*G mx*¹ and *G mx*². Gluteus maximus.
M. Semi-membranosus.
S. Sartorius.
T. Semi-tendinosus.
T a. Tibialis anticus.
T v f. Tensor vaginæ femoris.

MUSCLES OF THE HIND LIMB

§ 10. The *muscles of the hip and thigh*, though mainly taking origin from the pelvis and leg bones, yet partly arise from the loins.

The *gluteus maximus* consists of a great sheet of muscle and tendinous aponeurosis, and is more or less divisible into two parts one arises, by fascia, from the membrane covering the sacral region dorsally, and, by some muscular fibres, from the sacrum itself; the other part arises, by muscular fibres, from the first two caudal vertebræ. The first part is inserted into the great trochanter, at the base of its hinder outer part. The second part of the gluteus maximus is inserted into the femur below of the great trochanter, by means of a sheet of fascia (the fascia lata), which invests the thigh, dipping in between the adductor and the vastus externus, and descending right down to the external condyle of the femur.

The *tensor vaginæ femoris* is a large thick muscle which arises from the anterior end and anterior half of the ventral margin of the ilium and from the dense fascia intervening between it and the first part of the gluteus maximus. It is inserted into the *fascia lata*, which dips in (as before said) between the adductor and the vastus externus.

The *gluteus medius* is very large and fleshy. It arises from the whole outer surface of the ilium, and from the fascia between the

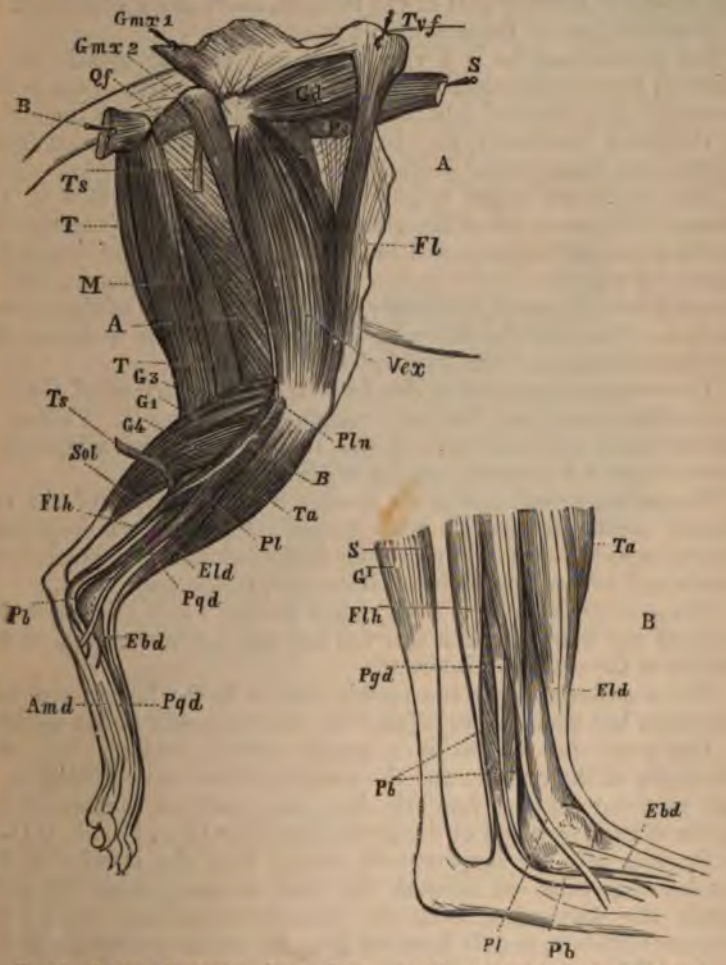


Fig. 83.—A. Deep Muscles of Thigh, Biceps, and Fascia lata, cut and reflected. B. Muscles and Tendons of Outer Side of Ankle.

A. Adductor.
A m d. Abductor minimi digiti.
B. Biceps femoris cut short.
E b d. Extensor brevis digitorum.
E l d. Extensor longus digitorum.
F l. Fascia lata.
F l h. Flexor longus hallucis.
*G*¹, *G*³, *G*⁴. Gastrocnemius.
Gd. Gluteus medius.
*G mx*¹ and ². Gluteus maximus.
M. Semi-membranosus.
P b, Peroneus brevis.
P l. Peroneus longus.
P q d. Peroneus quinti digiti
Pln. Plantaris.
Ps. Psoas.
Q f. Quadratus femoris
S. Sartorius.
Sol. Soleus.
T. Semi-tendinosus.
T a. Tibialis anticus.
Ts. Tenuissimus.
T v f. Tensor vaginæ femoris.
The rectus femoris is shown in the angle between *Gd* and *Vex.*

Gluteus maximus and the tensor vaginæ femoris. It is inserted into the great trochanter.

The *gluteus minimus* arises from the ventral part of the outer surface of the ilium behind and beneath the muscle last described; also from the anterior part of the ischium, above the acetabulum. It is inserted also into the great trochanter.

The *gluteus quartus* is a very small and delicate muscle which arises in front of the acetabulum just outside the origin of the rectus femoris. It is inserted into the front of the femur on the inner side of the great trochanter, *i.e.*, to the middle of the anterior intertrochanteric line, passing down between the vasti.

The *pyriformis* takes origin from the ventral surface of the sacrum. It passes out of the great sacro-sciatic notch (superficially to the great sciatic nerve, and in close apposition to and somewhat connected with the hinder surface of the gluteus minimus), and is inserted into the great trochanter within the insertion of the gluteus medius. This and the following muscles, up to and including the quadratus femoris, rotate the hind limb outwards.

The *obturator externus* arises from the outer surface of the obturator membrane and the bony margin surrounding it. Passing at first upwards and backwards, it ends in a strong tendon which turns outwards, and is inserted into the trochanteric fossa.

The *obturator internus* arises from the inner surface of the obturator membrane and its bony frame. Its fibres converge to a tendon which ascends, curves round the ischium and passes outwards and forwards to be inserted into the trochanteric fossa.

The *gemellus anterior* is a very small muscle which arises from the spine of the ischium and is inserted into the anterior margin of the tendon of the obturator internus.

The *gemellus posterior* is a muscle similar to the last in size and insertion, but which takes origin from the tuberosity of the ischium.

The *quadratus femoris* is a muscle which proceeds from the tuberosity of the ischium and the margin of the ischium below it, to the posterior intertrochanteric line and posterior surface of the femur at the lower end of the great trochanter (Fig. 83, *A*, *Qf*).

Psoas magnus is a large muscle arising from the interior of the trunk and passing out beneath the brim of the pelvis. It arises beside the diaphragm from the transverse processes of all the lumbar vertebræ, and is inserted into the lesser trochanter of the femur (*Ps*).

Iliacus.—This muscle is represented by fibres which arise from the inner surface of the ilium and blend with the psoas magnus.

The *psoas parvus* is but a subdivision of the psoas magnus, which subdivision ends in a strong tendon inserted into the ilio-pectineal eminence.

The *quadratus lumborum* is a muscle which arises (by a strong tendinous origin) from the outer margin of the ilium, half an inch behind its anterior end. Its fibres become closely connected with those of the psoas magnus, along the under surface of the lumbar transverse processes and onwards to the body of the twelfth dorsal vertebra.

These three muscles bend the pelvis or thigh upon the body, and *vice versâ*, and are of great use in running, bounding, and climbing.

The *pectineus* is a muscle which descends from the most anterior part of the symphysis pubis and ventral part of the brim of the pelvis to be inserted into the ridge which descends from the lesser trochanter to the linea supra, and into the linea itself. It is a small thin muscle, yet it extends half way down the thigh.

Except at its uppermost part it is inserted by fascia which is much connected with the muscle next described.

The *adductor* is a very large muscular mass, and is more or less

Fig. 84.—Muscles of inside of Thigh, Sartorius and Gracilis being cut and reflected.

A. Adductor.
A i. Abductor indicis.
Ex b. Extensor brevis digitorum.
Ex l d. Extensor longus digitorum.
Fl d. Flexor longus digitorum.
Fl h. Flexor longus hallucis.
G2. Gastrocnemius.
Gr. Gracilis.
M. Semi-membranosus.
Pec. Pectineus.
Pln. Plantaris.
Pop. Popliteus.
Ps. Psoas.
R f. Rectus femoris.
S. Sartorius.
Sol. Soleus.
T. Semi-tendinosus.
T a. Tibialis anticus.
T p. Tibialis posticus.
T v f. Tensor vaginæ femoris.
V in. Vastus internus.

incompletely divisible into several parts. It arises from the symphysis pubis, and from the pubis and ischium at each end of the symphysis. It is inserted by muscle into the whole length of the linea aspera, and into the space between the inferior bifurcation of the linea aspera, at the lower end of the back of the femur. It is closely connected at its insertion with the inner head of the gastrocnemius.

The *sartorius* arises from the most anterior part of the ventral margin of the ilium. It spreads out into a broad muscular sheet which invests the front and antero-internal part of the thigh, and

is ultimately inserted into the ligament of the patella and internal tuberosity of the tibia. Some of its muscular fibres extend down to the tibia below its inner tuberosity.

The *gracilis* is a wide, flat, muscular sheet, which arises by tendinous fascia from beneath the symphysis pubis, and is similarly inserted into the inner side of the tibia, its broad insertion being overlapped by the sartorius. Like the preceding muscle it is a flexor of the leg on the thigh.

Semi-tendinosus.—This is a long, subcylindrical muscle, which arises by tendon and fascia from the tuberosity of the ischium, beneath and a little behind the origin of the biceps femoris. It is inserted partly into the tendinous sheath of fascia which goes to the inner side of the tibia, and partly, by a very strong tendon, into the front of the tibia, about half an inch below the patella (Fig. 84, *T*).

The *semi-membranosus* is very thick and fleshy, and more or less double. It arises from the tuberosity of the ischium, and from the ramus of the ischium below the tuberosity down to the symphysis. It is much united in its course and insertion with the adductor. It is inserted into the inner condyle of the femur and above it up to the insertion of the adductor, and also by a strong tendon (which passes beneath the internal lateral ligament of the knee) into the internal tuberosity of the tibia (Fig. 74, *sm*). The part with the latter insertion arises within the origin of the other part, the muscle being near its origin folded on itself, with the opening of the fold forwards. The two parts are entirely separable for the last inch of their course. The part inserted into the inner condyle is closely connected with the internal head of the gastrocnemius.

Biceps femoris.—This is an enormous sheet of muscle, the fibres of which expand in a fan-like manner (Fig. 82, *B*). It arises (by muscle and strong tendon) from the tuberosity of the ischium, somewhat between the origin of the semi-tendinosus and semi-membranosus, but anterior to both. It is inserted by a tendinous fascia into the outer side of the leg from the top of the knee-joint nearly to the heel, but it is especially inserted into the outer tuberosity of the tibia.

The three muscles last described are called the hamstring muscles, and are powerful flexors of the leg.

Tenuissimus (Fig. 83).—This most delicate muscle arises from the caudal vertebræ at the front end of the second part of the gluteus maximus, with which it is intimately united. Passing down beneath the gluteus maximus and inside the biceps, it ends by blending with the inner surface of the latter muscle close to the anterior end of its inferior margin.

The *quadriceps extensor*, or great extensor of the leg, consists of four parts, which have a common insertion into the tendon of the patella, and, through it, into the tuberosity of the tibia.

The first part is the *rectus femoris*, and arises from the hinder part of the ventral margin of the ilium, and, by a tendon, from the antero-superior margin of the acetabulum.

The second part, or *vastus externus*, is of enormous size, wrapping

the rectus femoris in front. It from the whole outer surface of mur and great trochanter.

e third part, or *vastus internus*, s from the inner side and front of mur, right up to the capsular liga- (Fig. 84).

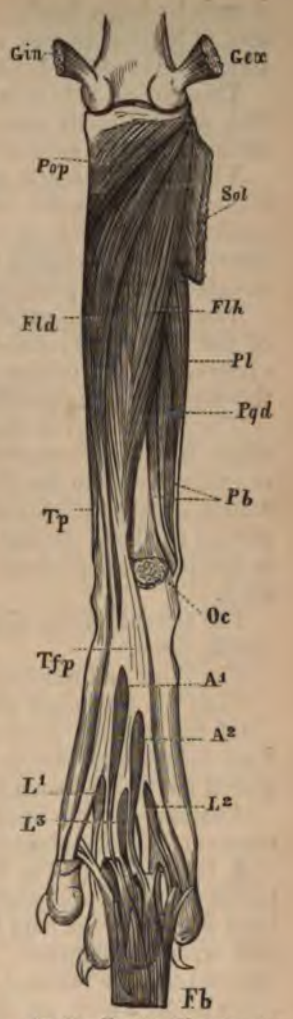
e fourth part, or *crureus*, arises from wer half of the front of the femur.

e leg has five long muscles in front even behind.

e *tibialis anticus* takes origin from ssa on the outer side of the upper of the tibia, from the adjacent part e fibula, and from the intervening osseous ligament. It is inserted by ng tendon into the dorsum of the entary first metatarsal. It covers the upper third of the extensor s digitorum, and its action is to the foot forwards and inwards on g.

e *extensor longus digitorum pedis* by a strong tendon from the pit on mur, which is situate just outside the margin of the groove for the patella. e ankle it passes through a strong ous loop devoted to it alone, and loop is attached to a concavity e upper surface of the os calcis, in of (below) the astragalus. Before g through the loop it is already d into four tendons, which go to terior sheaths of the four digits.

e *peroneus longus* is a very notable e which takes origin from the head e fibula around the attachment of xternal lateral ligament. It ends endon which passes down in front e external malleolus in a special e in the front of the fibula, which e is bridged over by a tendinous lined by synovial membrane. g superficially to the tendons of o muscles next described, it dips neath the deepest plantar muscles, traversing the channel formed for the groove beneath the cuboid and culiar process of the ento-cuneiforme,



ig. 85.—FLEXOR MUSCLES OF LEG, THE GASTROCNEMIUS, PLANTARIS AND SOLEUS BEING REMOVED.

A^1 and A^2. Accessorius.
F b. Flexor brevis digitorum, cut and reflected.
Fl d. Flexor longus digitorum.
F l h. Flexor longus hallucis.
Gex. External head of Gastrocnemius.
Gin. Internal head of ditto.
L^1, ^{2}, and ^{3}. Lumbrical muscles.
Oc. Os Calcis cut short off.
P b. Peroneus brevis.
P l. Peroneus longus.
Pop. Popliteus.
P q d. Peroneus quinti digiti.
Sol. Soleus.
T f p. Tendon of deep flexor muscle.
T p. Tibialis posticus.

it ends by being implanted into the inner end of that groove close to and at least indirectly connected with the minute innermost metatarsal—that of the hallux.

This muscle aids in walking by pulling up the inner side of the foot, and indirectly pressing the distal ends of the inner long metatarsals upon the ground as a fulcrum.

The *peroneus brevis* arises from the front and outer side of the lower half (or more) of the fibula—except close to the external malleolus. It ends in a tendon which passes behind the external malleolus, and beneath the tendon of the peroneus longus, and is inserted into the proximal end of the fifth metatarsal.

The *peroneus quinti digiti* springs from the upper and outer half of the fibula, and ends by a slender tendon which passes, in a synovial sheath, behind the external malleolus, and is inserted into the dorsum of the proximal phalanx of the minimus digit.

The *extensor brevis digitorum pedis* is a short muscle which takes origin from the concavity on the distal part of the dorsum of the os calcis and from the dorsum of the cuboid. It divides into three bellies, each of which ends in a strong tendon. The innermost tendon divides at about the distal end of the metatarsals, one division going to the proximal phalanx of the index, the other to that of the third digit.

The second tendon similarly divides, and goes to the third and fourth digits.

The third and outermost tendon goes to the fourth digit only.

Thus the fifth digit receives no tendon from this muscle.

Of the muscles behind the leg the largest is the *gastrocnemius*. Two heads respectively arise from the two sesamoids, which are placed one behind each of the two condyles of the femur.

Another (third) head arises from the ligamentum patellæ in common with the plantaris.

A fourth head (Fig. 83, 4) arises from the fascia investing the peronei muscles and fibula. The third and fourth heads, with the head from the sesamoid behind the external condyle, unite inextricably with the plantaris. The head from the sesamoid behind the internal condyle remains long distinct, but ultimately unites with the other heads which, all having united, end below in a strong tendon —the *tendo Achillis*—which is inserted into the hinder part of the tuberosity of the os calcis, superficially to the insertion of the soleus. Close to the heel, the tendon passes to the peroneal side of that of the plantaris, the latter there appearing and becoming superficial to it (Fig. 84).

The *plantaris* arises from the ligamentum patellæ in common with the third head of the gastrocnemius. Below this origin it is closely mixed up with the outer parts of the gastrocnemius—though well distinguished from the inner part of the latter. It forms below a strong tendon, which becomes visible just above the tuberosity of the os calcis on the tibial side of the tendo Achillis. It then expands and glides over the pulley-like surface of the calcaneal

tuberosity—its passage becoming facilitated by synovial membrane. It ends in the plantar fascia, which invests the under surface of the foot and gives origin to the flexor brevis digitorum.

The *soleus* arises from the summit of the back part of the fibula and is inserted into the tuberosity of the os calcis beneath (*i.e.*, covered in by) the tendo Achillis.

These three muscles raise the heel and are great agents in jumping.

The *popliteus* is a short oblique muscle, which takes origin by a thick tendon from and just outside the external condyle of the femur. It is inserted on the posterior surface of the tibia, above the oblique line and conterminous with the origins of the tibialis posticus and flexor longus hallucis (Fig. 85).

Flexor brevis digitorum or *perforatus.*—This muscle takes origin from the plantar surface of the plantar fascia of the plantaris. It is made up of four small muscles, placed side by side, which send tendons to the four digits; the muscle and tendon going to the fifth digit being the most slender. These tendons go to the second phalanges, but each splits opposite the proximal phalanx to allow a tendon of the flexor longus to pass through the perforation thus formed.

The *flexor longus digitorum pedis* or *preforans* is rather small, and arises from the hinder surface of the tibia, below the popliteus, from the summit of the fibula and from the intermuscular fascia between it and the tibialis posticus. It ends below in a tendon which passes down a groove behind—or rather on the inner side of—the internal malleolus. This groove is lined by a separate synovial membrane, and is just behind that for the tibialis posticus. The tendon passes into the plantar region and ends by dividing into four tendons, which are inserted into the distal phalanges of the digits after perforating the tendons of the flexor brevis.

The *flexor longus hallucis* is a large muscle which takes origin from the back of the fibula and tibia and interosseous ligament—below and external to the origin of the last described muscle. It ends in a tendon which passes in a synovial sheath behind the internal malleolus, and beneath the sustentaculum tali of the os calcis in a deep groove. It ends by coalescing with the tendon of the flexor longus digitorum. It is much connected with the peronei which border it externally.

Lumbricales.—There are three of these muscles in the hind-paw, and they resemble those of the fore-paw. One passes from between the deep flexor tendons of the index and third digits to the tibial side of the third digit. The second goes from between the deep tendons of the third and fourth digits to the tibial side of the fourth digit, and the third goes from the deep flexor tendon of the fifth digit to the tibial side of the same digit.

Accessorius.—This is a very small muscle of two bellies, which arise on the plantar surface of the conjoined deep flexor tendon, and end by two delicate tendons, which join the tendons of the flexor brevis, going to the third and fourth digits (Fig. 85).

Tibialis posticus.—This muscle lies deeply and takes origin from the hinder side of the tibia beneath the popliteus, and from the hinder surface of the head of the fibula. It ends below in a tendon which passes down the internal malleolus in a special groove placed close to, but in front of, the groove for the flexor longus digitorum. It ends by being inserted into the prominence at the hinder part of the inner border of the naviculare. This muscle is naturally quite covered in by the flexor longus digitorum, save where its tendon appears in front of that of the last named muscle.

The *abductor indicis* is a small muscle arising from the plantar fascia and tarsus at the root of the rudimentary hallux, and is implanted into the tibial side of the proximal phalanx of the index.

Opponens minimi digiti.—This is a narrow muscular band which arises from the plantar fascia at the root of the index digit, and is inserted into the metatarsal of the fifth digit.

Abductor digiti minimi.—This arises from the plantar surface of the os calcis, and is inserted by a delicate tendon into the peroneal side of the proximal phalanx of the fifth digit.

The *interossei* are a set of small muscular bundles—two to each digit, except the rudimentary hallux. They all take origin from the plantar surface of the proximal ends of the metatarsals, and pass upon either side of these bones to their distal ends. There they are inserted partly into the sesamoid bones (placed one beneath the distal end of each metatarsal) and partly they ascend (like those of the fore-paw) to be inserted into the extensor tendons.

The pelvic limb is, like the rest of the body, clothed with subcutaneous *superficial* FASCIA. In the thigh this takes the name of *fascia lata*, and is very dense (especially on the outer side of the limb) and sends down expansions between the muscles, one large expansion penetrating to the linea aspera.

The aponeurosis of the leg is continuous at the ankle with the anterior annular ligament, beneath which pass the extensor tendons.

The *internal annular ligament* passes from the inner malleolus to the heel, and transmits the flexor tendons.

The *external lateral ligament* passes from the outer malleolus to the heel, and transmits the tendons of the peroneus longus and peroneus brevis.

In the foot, as in the hand, synovial bursæ facilitate the passage of the tendons.

As to the STRETCH OF MUSCLES over the segments of the pelvic limb, there are certain muscles inserted into the pelvic girdle and proceeding to it from the trunk—as the abdominal muscles and psoas parvus; others proceed from the pelvic girdle to the thigh, as the glutei; others from the thigh to the leg, as vastus externus and internus, and the crureus; and finally, others from the leg to the foot, as the deep flexors of the digits.

But muscles may pass directly from the trunk to the thigh, as the psoas; or directly from the pelvic girdle to the leg, as the ham-string muscles; or directly from the thigh to the foot, as the gastrocnemius.

None of the muscles, however, which go to the digits arise from the femur, except the extensor longus digitorum pedis, while, on the contrary, some of the flexors and extensors—as the flexor brevis and the extensor brevis—take origin not in the leg but in the foot itself.

As to the NUMBER OF MUSCLES WHICH MAY BE INSERTED INTO A SINGLE DIGIT, we see that the ideal perfection of having both a flexor and an extensor inserted into every segment from the metatarsal to the last phalanx is only nearly attained in the digitus minimus. Thus its metatarsal is flexed by the peroneus brevis and extended by the peroneus tertius. Its first phalanx is flexed by the interosseus, and is more or less extended by (though it receives no tendon from) the extensor brevis. The second phalanx is flexed by the flexor brevis or perforatus, and is extended by the extensor digitorum longus. The third phalanx is flexed by the perforans or flexor longus, and more or less imperfectly by the interosseous and lumbrical muscle.

Besides these muscles the digitus minimus has also an abductor and an opponens.

§ 11. The DIFFERENCES between the muscles of the fore and hind limbs are the following:—The flexors and extensors of the pelvic limb arise lower down than do those of the thoracic limb. Nothing in the fore limb answers to the peroneus longus of the hind limb, while nothing in the leg answers to the supinator longus or to the extensores carpi radialis longior and brevior of the arm. In the fore-paw there is no accessorius, and its perforated muscle is a long one, while in the hind-paw it is a short muscle. There is a second (short) extensor of the digits in the hind-paw, there is none in the fore-paw. There is no long extensor tendon to the index and fourth digits of the hind-paw. The deep flexor tendons spring from one tendon in the fore-paw, from the conjoined tendons of two muscles in the hind-paw.

In the foot, the hallux being a mere rudiment, it has not muscles corresponding with those which the pollex has. Again, the hind-paw has that very peculiar muscle—the accessorius—to which nothing in the fore-paw appears to correspond.

The AGREEMENTS between the muscles of the two limbs may be expressed as follows:—The supra and infra-spinatus and teres minor are inserted into the pre-axial tuberosity, while the psoas and iliacus are inserted into the pre-axial trochanter. The subscapularis and teres major are inserted into the post-axial tuberosity, the glutei are inserted into the post-axial trochanter.

The triceps is the great extensor of the arm and the quadriceps of the leg. The biceps of the arm seems to be represented by the gracilis and sartorius of the leg. The coraco-brachialis corresponds with the adductor; the extensor ossis metacarpi pollicis with the tibialis anticus; the flexor carpi ulnaris with the peroneus brevis, and possibly also with the soleus and the gastrocnemius; the extensor carpi ulnaris with the peroneus tertius; the flexor carpi

radialis with the tibialis posticus; the flexor digitorum profundus with the flexor longus digitorum; the flexor digitorum sublimis with the flexor brevis digitorum; the extensor communis with the extensor longus digitorum; the palmaris longus with the plantaris; the pronator teres with the popliteus; while the lumbricales and interossei generally correspond in spite of the slight differences already noted.

§ **12**. Considered independently of the bony skeleton, the muscular system of the cat may, as its simplest expression, be conceived as a fleshy envelope of the body which takes the form, ventrally, of three superimposed layers (the fibres being directed differently in each layer), and dorsally, of a number of very various longitudinal bundles, ending in tendons directed more or less obliquely forwards. In the tail the envelope consists of longitudinal bundles, which, below as well as above, end in tendons directed more or less obliquely backwards. In the head, the muscular envelope becomes complicated for the hyoid, jaws, and organs of sense. The muscles of the limbs may be conceived as sheaths of fibres forming a median and two lateral groups of muscles, both on the extensor and flexor surfaces of each limb, with special modifications and subdivisions where each limb becomes subdivided into its terminal digits.

CHAPTER VI.

THE CAT'S ALIMENTARY SYSTEM.

§ 1. In the first chapter of this work it was pointed out that the great function of sustentation * was in part brought about by the process of *alimentation* and in part by *secretion*.

Alimentation is effected by the reception of new elements into the very ultimate substance, or parenchyma, of the body. This process is called *assimilation*, and consists in the transformation of what is immediately external to the parenchyma into the parenchyma itself —the change of the flesh and blood of other creatures into cat-flesh and cat-blood. As to this process, science can only say that it is performed, the ultimate "how" of the transformation is an altogether insoluble problem.

Nevertheless certain physical properties and conditions, to be adverted to shortly, help us to understand various digestive and other processes which serve and lead up to the final act of assimilation. Assimilation is always effected from a fluid medium derived from the food; but in order that the food should be able to supply the body with such a medium, it must, sooner or later after its reception, undergo a certain process of preparation. Thus the whole process of nourishing the body by food—the process of alimentation—is made up of three subordinate processes: (1) the reception of the food, (2) its preparation, and (3) its assimilation.

But that the life of the cat may be maintained, nutriment is by no means the only requisite. It is also necessary that a certain temperature should be maintained by a constant process of oxygenation of the body's substance, which temperature may be greatly above or somewhat below that of the surrounding air. Thus two classes of supply are called for: (1) matter for the nutrition of the tissues, (2) matter to serve for the production of warmth. Both these matters together constitute what is known as "food."

§ 2. As to the kinds of food required by the animal we are considering, it must evidently be supplied with what contains the requisite materials for forming all its tissues, since all of them, even the very bones, are being slowly changed and renewed piecemeal

* See *ante*, p. 10.

during life. Now every tissue, as we have seen, can ultimately be reduced to oxygen, hydrogen and carbon, with or without nitrogen, and a few other elementary substances, in greater or less quantity. But let the cat be supplied, however plentifully, with these elements in whatever forms or combinations which are merely chemical, and it would none the less infallibly starve; for it has no power of building up from inorganic matter, the very complex substances of which its body is formed. It absolutely requires to be supplied with compounds which have been ready formed for it by other creatures—it must feed on living or recently dead animal or vegetable substances. Such inorganic matters as water with the salts which may be dissolved within it, do, however, form part of its food.

The organic substances on which it lives, may, like its own tissues, be divided into the nitrogenous and the non-nitrogenous, and there are two sets of each of these kinds.

One set consists of *albuminoid* substances, such as the blood and flesh of the animals on which it may prey. Their connective tissues, cartilage, and bone, are examples of *gelatinoid* substances, and of such the second set of nitrogenous foods consists.

Oleaginous substances (or fats and oils) and *amylaceous* substances —sugar, starch, and gum—are the two sets of non-nitrogenous foods. The last set are mainly of vegetable origin, but there is a sort of starch (glycogen) in the livers of animals, while muscle has a sugar of its own (inosite), and there is a sugar of milk.

Much oxygen (as we shall hereafter see) is also received into the body by the lungs in respiration.

The products of that WASTE of the tissues which is inseparable from the wear and tear of life (and which necessitates the acquisition of food) are eliminated in various ways by the lungs, kidneys, and skin, and the undigested residue of what has been eaten is cast forth from the alimentary canal itself.

The process of nutrition effected by food is, in the early life of the animal, greatly in excess of waste, but at maturity a practical equilibrium is established, which is maintained till, with the advance of age, the balance at first existing becomes reversed.

§ **3.** As has been said, secretion is closely connected with alimentation. That it must be so will clearly appear if we reflect that "secretion" is an action by which certain portions of the body extract from the blood new substances (the various secretions) which do not exist as such within it, and that "nutrition" (the culmination of the alimentary process) is an action by which certain portions of the body extract from the blood new substances (the various tissue-substances) which do not exist as such within it. Every part of the cat's body which can be nourished must necessarily have this power or the cat could not repair the effects of its own waste when adult, or "grow" during immaturity. In "nutrition," however, the formed product enters into the composition of the body itself, while in secretion this is not (directly at least) the case

—the product being discharged from some surface external or internal.

But in fact it is not the blood alone which is in all cases the direct source of nutrition, since the blood has the power of replenishing itself and repairing its losses out of the fluids obtained from the food. The intimate way in which assimilation takes place, is named INTUSSUSCEPTION, to distinguish it from any growth which may take place by mere external addition—as when a crystal grows, while suspended in a suitable medium, by the deposition of fresh matter on its surface.

Another process, which is ancillary to nutrition and secretion, is termed ABSORPTION, which is the generic term applied to the introduction into any tissue of the body, of substances external to it, and thus nutrition, or assimilation, itself is, in fact, one form of absorption. The process of absorption is aided by the physical properties termed *endosmosis* and *exosmosis*, terms which denote the passage of fluids in opposite directions through dead animal membranes; different fluids, when thus divided, tending to pass through to the other side of such membranes with different degrees of rapidity.

Dialysis is the term used to denote this movement of transfusion, irrespective of its direction, and therefore includes both endosmosis and exosmosis.

§ 4. It has been found that different substances may be arranged in two classes according to their diffusibility, and that this division coincides with certain other characters which the two classes, termed respectively CRYSTALLOIDS and COLLOIDS, present. All crystalloid bodies are crystallisable ones. When dry, they are hard, rigid, and quickly soluble; their solutions are never viscous, they are always more or less sapid, and they are highly diffusible. Colloids do not crystallize, and when dry they are tough. They dissolve slowly, and their solutions are more or less viscous; they are insipid, and they diffuse with difficulty. Albuminoid and gelatinoid substances are colloids.

Dialysis doubtless takes place in the living body: as in secretion, nutrition, and absorption, and it is possible that some such process may be the cause antecedent to muscular contraction. All salts and other crystalloid matters, whether useful, indifferent, or hurtful, readily find their way into the substance of the body from the alimentary canal, but, as we shall see later, this ready penetration of very diffusible substances is not the same thing as true intestinal absorption where a selective power is manifested. This latter active kind of absorption is, as has been already said, analogous to secretion.

§ 5. The consideration of the distinctions which exist between colloids and crystalloids leads us to the last preliminary consideration, namely, to that of the process of DIGESTION. This process consists in the reduction of food to a state in which it can be readily taken up into the system, and since it cannot be so taken up except

by passing through the substance of limiting membranes, it is obvious that this process must be synonymous with an increase of the food's diffusibility, a quality acquired in part by a change in its chemical composition, in part by its very minute subdivision.

Minute subdivision is produced by mastication, by the contraction of the walls of the alimentary canal, and by the influence of fluids poured into that canal, and which reduce the fatty matter of the food to the condition of an emulsion.

Diffusibility is produced by a transformation of colloids into crystalloids, starchy matters being changed into that highly soluble crystalloid, sugar; and the albuminoid and gelatinoid substances, being transformed into albumen-peptone and gelatin-peptone, both of which are capable of ready absorption. These transformations are effected by the agency of certain fluids which different parts of the alimentary organs secrete and pour into the alimentary tract.

These facts and considerations throw a certain light on the process of alimentation. But any explanations to be thence derived are manifestly most incomplete, because the very living membrane itself can cause changes in the fluid itself as it passes through it, and the living particles of parenchyma exercise a certain power of choice with respect to the contents of the fluids in contact with them. Such particles are not passive bodies, but active, living agents, and their action no one has yet really explained.

§ **6.** The processes of alimentation may then be SUMMARIZED as follows:—

To support life by due repair of waste, and the maintenance of the necessary body temperature, food is required of such a nature as to furnish the substance of the tissues, and to serve as fuel. This food must be minutely comminuted, or rendered soluble by mechanical action, and by the influence of suitable fluids. When this process of digestion has been accomplished, the nourishing product becomes more or less completely absorbed, and, passing into the blood-stream, regenerates it, and through it supplies every part of the frame with fresh material, which is taken up by internal assimilation or intussusception, and transformed into the substance of the living body—the non-nutritious, non-absorbed residua being discharged.

This great function is subserved by an elaborate apparatus, commonly known as the stomach, intestine, &c., with their annexed organs. It may be shortly described as a convoluted tube of different capacity in different parts, passing from one end of the body to the other, with two terminal apertures and with muscular walls, the fibres of which are so arranged as, by their regular, alternate contraction and relaxation, to drive the contents of the tube onwards from its anterior to its posterior termination.

The anterior part of the tube is enlarged and specially modified to serve for the reception of the food, its subdivision and preparatory moistening by certain fluids. This is the *buccal cavity*, or mouth,

with its lips, jaws, teeth, tongue, palate, fauces, and salivary or spittle glands.

Next follows the part immediately behind the mouth, called the *pharynx*, which opens into the *gullet* or *œsophagus*, which perforates the diaphragm and leads into that dilated chamber the *stomach*. To this immediately succeeds the small, and afterwards the large, *intestine*—with a blind off-shoot, the *cæcum*, at their point of junction—the whole terminating by that part of the canal which is called the *rectum*. Annexed to the canal (pouring fluids into it of great importance to the alimentary function) are the *pancreas* and the *liver*, and that part of this whole complex system of organs which is behind the diaphragm, lies suspended in the abdominal cavity by a delicate and very complexly-folded membrane, the *peritoneum*.

As we have already seen* in the second chapter, the skin which is reflected inwards at the mouth, nostrils, and other body apertures, assumes a soft and delicate texture with a moistened surface, and is known as mucous membrane. We have also seen that the whole of the alimentary tube, and the structures opening into it, are lined by this membrane. The epithelium, which everywhere invests its surface, may be of the columnar form (as in the stomach and intestine), or spheroidal, as in the linings of the alimentary glands. Its corium may contain abundant connective tissue (with many elastic fibres), as in the gullet, or there may be but little, as in the walls of the stomach. It may be so richly supplied with minute blood-vessels, immediately beneath the basement membrane, as to seem almost made up of them, while its deepest layer often consists of non-striated muscular fibres. It is also richly supplied with nerves, but their number varies greatly in different regions, as does the sensibility of the parts.

As to the form and nature of the prominences—villi, papillæ, &c.—which beset its surface, they also are very different in different parts of the alimentary tube.

§ **7.** A fluid, named MUCUS, is almost universally present where mucous membrane exists, and gives its name to that membrane. It is an alkaline or neutral secretion, viscid, colourless, and clear or slightly turbid. It consists mainly of water, but has from 4 to 6 per cent. of solid matter, and contains corpuscles. Its special constituent is an albuminoid substance named *mucin*, which is the cause of its viscidity. Mucus is formed by the epithelial cells of mucous membrane, but especially by certain branching or "racemose" glands. Its use is to preserve the moisture of the membrane, and also to protect it from the dissolving action of the various digesting fluids. It doubtless also helps the senses of taste and smell, partly by preserving the moisture of the surface of the organs of those senses; partly by helping to dissolve the various sapid matters.

* See *ante*, p. 25.

§ 8. The cat's MOUTH is bounded externally by the lips, which form a single fold around the lower jaw, and two folds, separated by a median notch, around the upper jaw. Inside the lips, folds of membrane called *frœna*, proceed inwards, and bind them to the gums, which are masses of dense fibrous tissue investing the alveolar margins of the jaw-bones and covered by mucous membrane of a smooth and highly vascular character. Laterally, the mouth is bounded by the cheeks; it is bounded below by the tongue and the soft parts which connect the tongue with the mandible. Above, it is bounded by the palate within the upper alveolar margin. The lips and cheeks are composed of muscles and skin (as already described), together with blood-vessels, nerves, and fat. The mucous lining of the mouth abounds in small glands, of which those inside the lips are called "labial" and those inside the cheeks "buccal." On the palate, the mucous membrane, where it invests the bones, is raised into about eight (Fig. 86) curved, transverse, permanent ridges or *rugæ*. Beyond the bones, the palate is continued for a long distance as "the *soft palate*" (investing the muscles already noted), and which hangs down from the hinder edge of the palatine bones like a curtain, and is therefore called the *velum palati*. The palate abounds in small "palatine glands." The middle part of the free edge of the velum presents a slightly marked notch. Two folds of membrane descend, diverging as they descend, from either end of the velum (see Fig. 87, *p*, and in front of *t*). These folds form what is called the anterior and posterior "pillars of the fauces," or the *isthmus faucium*. The term "fauces" is used to denote that posterior aperture of the mouth which is bounded laterally by these pillars, above by the velum, and below by a structure rising up behind the tongue, and hereafter to be described as the "epiglottis."

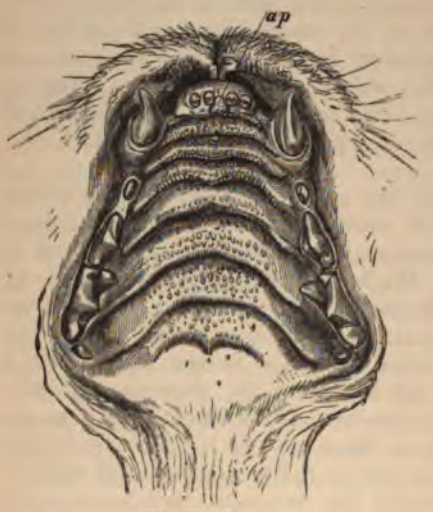


Fig 86.—PALATE.

ap. Anterior palatine foramen.

In this view the small upper molar is well seen, as also the inner tubercle of the sectorial tooth

Between the anterior and posterior pillar of the fauces on each side is a large horizontally-placed crescentic depression (with numerous openings of follicles* scattered over its floor), called a *tonsil* (Fig. 87, *t*). The use of the tonsils is unknown.

* A "follicle" is a minute simple bag-shaped gland.

The parts destined to subdivide the food, the teeth, have been already described.* The adaptation of the sectorial teeth for the division of flesh is manifest and admirable. The canines are not used for dividing the food. They are weapons for seizing and destroying prey, or for combat. The incisors are of little functional utility, but they help to scrape off flesh and sinews from the surfaces of bones. The upper true molars are so small as to be of little service, but their shape and position adapt them for crushing any suitably sized object (such as a small piece of bone) which may have been taken into the mouth.

Fig. 87.—DORSUM OF THE TONGUE OF THE CAT.

a. Arytenoid cartilage.
cv. Circumvallate papillæ.
e. Epiglottis.
f. Fungiform papillæ.
p. Posterior pillar of fauces.
s. Conical papilla.
t. Tonsil.
v. Vocal cord.

§ **9**. The TONGUE fills up the cavity of the mouth between the horizontal rami of the mandible. It is a muscular mass, coated with mucous membrane, attached behind to the hyoid and below to the membrane of the floor of the mouth, but with a free apex. It is long and flat, with nearly parallel sides, tapering slightly in front and more so at its posterior attachment.

Its fleshy mass is principally composed of transverse fibres which pass directly right and left from a central, vertical membranous septum. This mass of transverse fibres is traversed by ascending fibres of the genio-hyoglossus muscle, and is coated externally by longitudinal fibres which form its cortical muscular layer. Above and below, these fibres belong to two muscles; one, called the *lingualis superficialis superior*, proceeds forwards from the basi-hyal, and the other, called the *lingualis superficialis inferior*, passes thence on each side of the ascending fibres above mentioned. The lateral longitudinal fibres come from the stylo-glossus and hyo-glossus. This mass of muscular fibres enables the tongue to move freely in all directions and to modify its own shape.

Imbedded in the areolar tissue of the septum and near the lower surface of the tongue is a spindle-shaped body (formed of fibrous tissue, fat and muscular fibre), connected anteriorly with the mucous membrane of the tongue, and tapering off behind till it is lost in the tissue of the septum. This body is the *lytta* or "worm."

* See *ante*, p. 27.

Its function is unknown, but it is supposed to help the tongue in it lapping action.

The mucous membrane, which invests the tongue, forms a fol beneath it and in front (attaching it to the lower jaw) termed th *frænum linguæ*, and thence it is continued onwards (over the muscle forming the soft floor of the mouth) till it reaches the gums. A minute process—the *salivary papilla*—projects forwards on eac side of the frænum.

The upper surface of the tongue is flat, with a depressed are behind, which is bounded posteriorly by the epiglottis—or cartilag guarding the entrance to the windpipe.

The surface of the tongue is smooth beneath, but above it is bese with papillæ of four kinds:—

(1.) The first are the *circumvallate papillæ*, each of which consist of a flattened prominence (shaped like a truncated, inverte cone), with a sort of trench round it. A few of these are dis posed in two rows converging posteriorly like a widely ope letter V (Fig. 87, *cv*).

(2.) The *fungiform papillæ* are much smaller and more numerou than the circumvallate ones. Each is somewhat swollen an rounded at its tip, while it is smaller at its point of attach ment. These papillæ (*f*) are found especially at the sides o the anterior part of the tongue.

(3.) The *conical papillæ* are very numerous and closely set ove the dorsum of the tongue, with their apices directed back wards. They are small and simple near the edges and tip o the tongue, but over the greater part of the dorsal surface the are much larger and horny in consistency—like so man minute claws—especially towards the middle line. It is th presence of these horny papillæ which makes the cat's tongu so rough and rasp-like.

(4.) The *flattened papillæ* are a group of very large, soft, flattene and pointed papillæ, placed behind the circumvallate papill on the dorsum of the root of the tongue.

§ 10. Besides the secretion of the small mucous glands, th cavity of the mouth is moistened by the product of various kinds o

SALIVARY GLANDS.

The first of these, the *parotid*, is a branching, or racemose,* gland, consisting of many lobes held together by their excretory tubules, blood-vessels, and areolar tissue, and lined throughout with epithelium. It forms a crescentic mass, with its concavity applied to the under and anterior aspect of the cartilage at the root of the external ear, its lower border being prolonged downwards and forwards (Fig. 88, *p*). Its duct (called Steno's or Stenson's) runs forwards across the mas seter muscle, and perforating the buccinator, opens inside the cheek opposite the sectorial teeth. Two small separate accessory portions

* For a description of the different varieties of glands, see § 8, in the chapter on the Organs of Respiration and Secretion.

lie opposite each other, one at the front margin of the parotid and the other at its hinder margin. Another supplementary *gland* (*f*), of an elongated oval shape, lies beside Steno's duct and opens into its cavity. It may be distinguished as the *facial gland.*

The *submaxillary gland* (*sm*) is rather smaller than the parotid and more rounded. It lies behind the angle of the mandible, and is in contact above with the downward prolongation of the parotid

Fig. 88.—VIEW OF SALIVARY GLANDS AND PARTS ADJACENT.

b. (At angle of mouth) buccal glands
b. (Near ear) anterior or accessory parotid.
b. (At beginning of throat) the two accessory sub-maxillary glands with the facial vein passing between them.
d. Duct of parotid gland (Steno's duct).
f. Facial gland.
jv jv. External jugular vein and (more anteriorly) facial vein.
l. Hinder accessory parotid.
n. Facial nerve.
sm. Sub-maxillary gland.
The duct of this gland is shown running forwards above and nearly parallel with the vein *jv*, a branch from which crosses over it.

before mentioned. Its duct (called Wharton's duct) runs forwards beneath the facial vein and opens on the minute salivary papilla before described as being situated beside the frænum of the tongue.

There are two accessory submaxillary glands which lie side by side (separated by the facial vein (Fig. 88, *jv*) immediately adjacent to the lower and anterior end of the principal submaxillary gland.

Another gland, called *zygomatic*, is of rather large size and pyramidal shape. It lies beneath the globe of the eye on the orbital plate of the maxilla and inside the anterior end of the zygoma. It opens in the mouth behind the upper true molar.

The *buccal glands* are small glandular aggregations, each aggregation opening by various minute orifices into the mucous membrane of the mouth.

The secretion of all these glands constitutes the SALIVA, which is a clear, alkaline fluid, consisting mainly of water, but containing nucleated corpuscles, a peculiar albuminoid substance called *salivin*, or *ptyalin*, and a minute quantity of sulphocyanide of potassium.

This secretion is poured out as it is formed, and its flow is accelerated by the contraction of the cheeks and tongue. The secretion is stimulated by the presence of food in the mouth, and even by the sight of it.

The action of this fluid on the food is, first, to soften it and dissolve what is soluble, including all its crystalloids. It has no action on the albuminoid or gelatinoid substances, nor on the fats; but it tends to convert starch (at the ordinary temperature of the inside of the mouth) into grape-sugar, thus changing a colloid into a crystalloid, and so rendering the starch soluble and capable of undergoing absorption and assimilation. This action, however, is slow and feeble in the cat. It is the ptyalin which has this power, which it seems to exercise simply by the stimulating action of its presence and contact; for if it is precipitated by alcohol, filtered, and then redissolved, it will quickly transform as much as 2,000 times its weight of starch into sugar.

The food having been sufficiently bitten, it is thrust backwards by the tongue through the isthmus faucium. While it passes, the velum palati is raised, and so guards the posterior nares from the intrusion of the food, and the backward motion of the tongue depressing the epiglottis, while the food passes over it, guards the entrance of the windpipe against the entrance into it of any alimentary matter.

§ 11. Immediately behind the isthmus faucium is a conical cavity, wider towards its upper part, and more contracted below. This is the PHARYNX. It rises up behind the mouth and posterior nares to the base of the skull, and forms the summit of that canal which leads down from the mouth to the stomach. It consists of the pharyngeal muscles already described, with a lining of fascia and mucous membrane, together with vessels, nerves, and areolar tissue. It is attached above to the basi-sphenoid and petrosals, and to the basi-occipital by a fibrous membrane, which passes down between the recti antici muscles. It is loosely connected behind with the fascia, investing the pre-vertebral cervical muscles, and laterally with the muscles attached to the hyoidean anterior cornu. In front, it is connected with the pterygoids, the hyoid apparatus, and the larynx.

There are seven openings into the pharynx. These are: the two posterior nostrils; and external to these, the two Eustachian tubes; in front, the mouth; and below it, the larynx; while inferiorly, the pharynx opens into (being continuous with) the œsophagus. Its mucous membrane is beset throughout with simple glands, while racemose glands are numerous in its upper part.

Its epithelium is squamous, except on the hinder surface of the velum palati, and in the upper (or nasal) region of the pharynx, where we meet with CILIATED EPITHELIUM. This very remarkable tissue consists of epithelial particles—nucleated cells—generally columnar in form, each having, freely projecting from its surface, from six to thirty thread-like processes, each from $\frac{1}{4000}$ to $\frac{1}{2500}$ of an inch in length (Fig. 11), like miniature human eye-lashes—whence their name.

These minute processes have the wonderful property of performing constantly during life, and (in a warm atmosphere) for as much as forty-eight hours after death, repeated lashing movements; each cilium bending itself with great rapidity, and then becoming more slowly straightened. All the adjacent cilia move in the same direction, thus producing a wave-like motion similar to that of a field of corn under a strong wind.

The result of these multitudinous and constantly-repeated minute motions—each repeated about ten times in a second—is to propel small particles along the ciliated surface of the body.

If a ciliated cell be detached, so as to float freely in some suitable fluid, then the effect of this action of its cilia is to move about the cell itself as by a sort of locomotion. Water checks the action of cilia, but blood will preserve it even for two or three days; such action still continuing on slips of membrane detached from the body. No muscular tissue and no nerve has been detected in the ciliated cells, nor are the actions of the cilia amenable to nervous or moderate electrical influence. They persist in the membrane which bears them when this is detached. The cause of their motion is as yet utterly inexplicable, an ultimate mystery like that of the contractile power of muscular tissue.

The FUNCTION OF THE PHARYNX is to direct the food which has just been pushed, through the isthmus faucium, downwards towards the stomach by means of successive contractions of its fibres from above downwards. It becomes more powerfully grasped as it approaches the œsophagus. This active prehension of aliment equally takes place when that aliment is fluid, none being allowed simply to fall down towards the stomach while the walls of the alimentary tract remain passive.

§ **12.** The gullet, or ŒSOPHAGUS, is a narrow, cylindrical tube, beginning at the bottom of the pharynx and extending downwards through the diaphragm, to terminate (immediately it has passed through that partition) in the stomach. It extends along above the trachea and heart, and beneath the vertebral column and longus colli muscle, being connected with those parts by lax areolar tissues.

It is, of course, lined with mucous membrane, the surface of which is covered with squamous epithelium.

The mucous membrane of the upper part of the œsophagus is folded (when the passage is not distended) in a number of vertical folds.

The lower end of the œsophagus, for a short distance before

entering the stomach, has its mucous membrane eleva
transverse folds, which may be called "quasi valvulæ conni
Outside the mucous membrane is a layer of areolar tis
outside that is a thick
coat of two layers—the
each being spirally dire
those of the inner lay
the more horizontal, a
of the outer layer t
longitudinal. Those of
layer are very thin, and
every here and there.
much striated fibre at t
part of the tube.

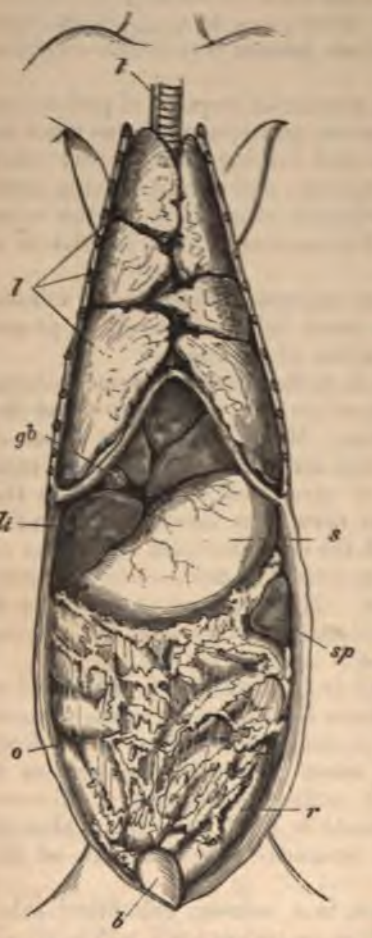


Fig. 89.—View of the Cat's Viscera, in situ, the Body being opened on its ventral aspect.

b. Urinary bladder.	*o*. Omentum.
gb. Gall bladder.	*sp*. Spleen.
l. Lung.	*t*. Trachea.
li. Liver.	*s*. Stomach.
r. Rectum.	

§ 13. The abdominal
is bounded above by
tebral column and mus
terally by the abdominal
in front by the diaphra
behind by the muscular a
branous partition, whic
posteriorly the cavity
pelvis.

On the middle of th
wall of the abdomen the
front a slight irregularity
face, which is the "na
umbilicus.

When the abdomen is
by a median antero-
section through its vent
and by the reflection
walls bordering the cut,
lowing organs come into

Immediately behind
phragm on the right sid
the liver (*l*), with the gall
protruding from amongst
In the middle line, partly
the liver, is the stomach
the extreme right of
the spleen (*sp*). Fr
stomach a flap of me
loaded with more or
and called the great omen
extends towards the pelvis, like an apron, and conceals t
deeply situated viscera. When this is turned up or ren
capacious transverse sacculated viscus may be seen to proce
versely behind (below) the stomach; this is the *great intestine*

hich are the multitudinous folds of a narrower tube—the *small testine*—while superficially, at the posterior end of the abdominal vity, the bladder (*b*) may be seen.

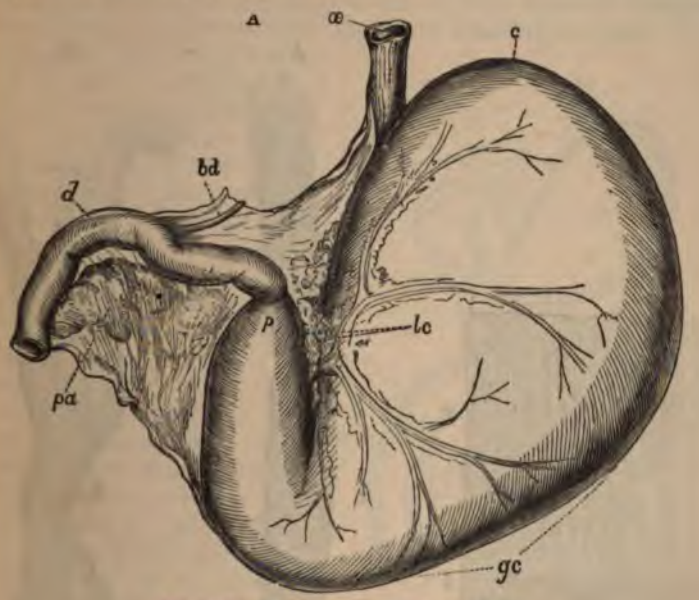


Fig. 90.—The Cat's Stomach and Pancreas.

A. Left aspect of stomach.

c. Cardiac portion.
bd. Bile duct.
d. Duodenum.
gc. Greater curvature.
lc. Lesser curvature.
œ. Œsophagus.
p. Pylorus.
pa. Pancreas.

B. Pancreas.

The pyloric part of the stomach is cut open to show the pyloric valve.
d. Duodenum.
p. Pylorus
d c c. Ductus communis choledochus.
p d. Pancreatic duct.

§ 14. The STOMACH is a dilatation of that part of the alimentary tube which lies immediately behind the diaphragm, rather to the

left. It is somewhat pear-shaped, but sharply bent upon itself. Its left and much larger end (*c*), is called the *cardiac end*, or *cardia* (because it is the nearer to the heart), and it is towards this end

Fig. 91.— VERTICAL TRANSVERSE SECTION OF THE COATS OF A PIG'S STOMACH, MAGNIFIED 30 DIAMETERS.

a. Gastric glands.
b. Deeper layer of mucous membrane.
c. Sub-mucous or areolar coat.
d. Circular muscular layer.
e. Longitudinal muscular layer.
f. Serous coat.

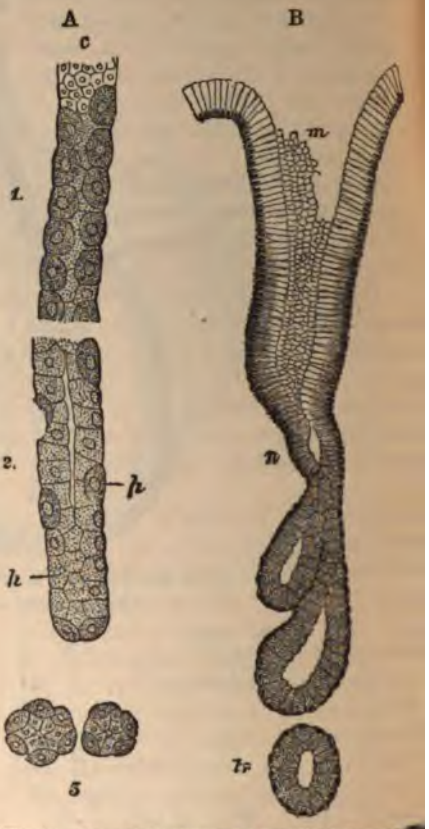


Fig. 92.—GASTRIC GLANDS FROM THE DOG'S STOMACH, HIGHLY MAGNIFIED.

A. Portions of a simple tubular "Peptic" gland.
1. Neck of the gland.
2. Fundus.
3. Transverse section.
p. Peptic cells.
h. Central cells.
c. Ends of columnar cells.
B. A gland of more complex shape.
m. Mouth.
n. Neck.
tr. A deep portion cut transversely.

that the œsophagus (*œ*) opens into the stomach. Its opposite end called the *pylorus* (*p*), and is directly continuous with the intestin the aperture by which the stomach opens into the latter being calle the *pyloric* orifice.

Its deeply concave surface between the œsophagus and pylorus i

its "lesser curvature (*lc*). The opposite very convex side
ed its greater curvature (*gc*).
tructure is essentially similar to that of the œsophagus. Its
lar coat, formed of organic fibres, consists of an outer radiating
directly continuous with the more longitudinal layer of the
agus. Within this is a
of circular fibres which
s over the whole sto-
and is especially thick
pylorus, where it forms
ncter which, project-
wards, constitutes (with
tissue and its mucous
what is called the "py-
alve" (Fig. 90, B, *pv*).
hin the second muscular
is yet a third set of
ly disposed fibres.
ediately within the
lar stratum is a layer
mucous *areolar* tissue,
directly supports the
lining of the stomach.
ining is soft, thick, and
, and is so loosely
ted by the areolar layer
he muscular coat, that
hrown into numerous,
r, undulating effaceable
when the stomach is
istended. The inner
of the stomach is
here beset with small
which are the orifices
ute close-set gastric and

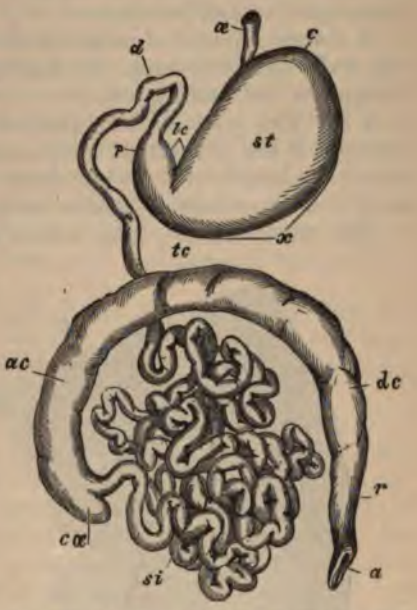


Fig. 93.—The Intestinal Tube of the Cat, seen ventrally, with its folds somewhat separated.

a. Anus.	*lc*. Lesser curvature.
ac. Ascending colon.	*p*. Pylorus.
œ. Œsophagus.	*r*. Rectum.
c. Cardia.	*si*. Small intestine.
cœ. Cæcum.	*st*. Stomach.
d. Duodenum.	*tc*. Transverse colon.
dc. Descending colon.	*x*. Greater curvature.

glands, which may be simple tubes or more or less branching.
he lower end of the œsophagus the squamous epithelium ceases
ves place to what is mostly of the columnar kind.

FUNCTION of the stomach is partly mechanical, since by their
ctions, its many muscular fibres rotate its contents, and so
all parts in turn to the action of its secreting walls while they
t towards the pylorus, and send through that aperture such
is of it as are sufficiently dissolved or soft. Regurgitation of
nto the œsophagus is prevented by the contraction of the
r fibres which surround its entrance into the stomach. The
action of the stomach is digestive through the *gastric juice*.
onsists of water, with some two per cent. of saline matters,
ute quantity of free hydrochloric acid and a little more
hree per cent. of *pepsin*, a neutral, albuminoid substance.

The gastric juice is colourless, or pale yellow, and strongly acid. Its action on albuminoids and gelatinoids is to change them into an extremely soluble form called *peptone*. It has no direct action on the amylaceous foods (rather arresting the process of converting starch into sugar) nor on the oleaginous matters. The contents of the stomach when all the action of that organ has been brought to bear upon it, is called *chyme*.

A certain amount of matter is directly absorbed by the vessels of the walls of the stomach, but this function is far more perfectly performed by the small intestine.

§ **15.** The part of the alimentary canal which succeeds the stomach is the INTESTINE, which is so convoluted as to be about five times the length of the whole body in the domestic cat, though it is said to be considerably shorter in the wild cat.

The part of this tube which comes first, is called the *small*

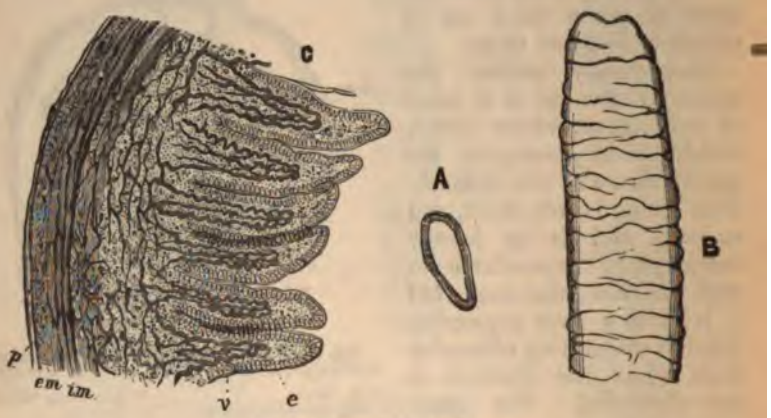


Fig. 94.—INTESTINAL VILLI.

A. Section through the small intestine, showing the numerous villi, with their orifices directed towards the central cavity.
B. A single villus, greatly magnified.
C. Section of the wall of the intestine, and of a few villi less magnified than Fig. B.

e. Epithelium.
em. External muscular layer.
im. Internal muscular layer.
p. Peritoneal investment.
v. Vessels within a villus.

intestine, and is very much longer, though smaller in calibre, than the succeeding portion. It is also by far the most convoluted part of the alimentary tube. It is cylindrical and about three feet eight inches in length, and of nearly the same diameter throughout. It is spoken of as consisting of three parts: the duodenum, jejunum, and ileum.

The *duodenum* comes next to the stomach, and describes a rather wide curve, which embraces the pancreas and receives its duct and also that from the liver. It lies on the right side of the abdomen. The *jejunum* is its continuation thence to the right side, and to it succeeds the mass of the small intestine which is formed by the *ileum*, and lies at the posterior and middle part of the abdominal cavity.

The inner surface of the small intestine does not form transverse folds, but is clothed with a velvet-like lining made up of a multitude of very fine, short, closely-set filaments or *villi*. These filaments are prolongations of the corium, invested with columnar epithelium, and contain blood-vessels, and a central vessel which is not a blood-vessel, but is called a *lacteal*. The lacteals open proximally into vessels belonging to the same category as they themselves do, and which lie in the submucous areolar tissue.

The lining of the small intestine is also beset with glands. The most noticeable of these are aggregations of glands, which aggregations go by the name of *Peyer's patches*. There are in the small intestine some six or seven of such patches, more or less narrow and elongated, especially the one at the posterior end of the ileum, which is clothed with villi like other parts of the intestine. Each patch is made up of a number of glands, or vesicles, smaller than a pin's head, composed of connective tissue, and containing a whitish fluid with nucleated cells.

Besides these structures, small glands of *Lieberkühn* (like the simple glands of the stomach) abound between the villi, and there are other glands called *Bruner's* glands, which are branching structures, most numerous in the duodenum.

The small intestine is composed (1) of an outer or *serous coat*; (2) of two muscular layers; (3) of an areolar or submucous coat; and (4) of the mucous lining. The serous coat is the peritoneal investment of the intestine, which is continuous with the two layers of the mesentery by which it is suspended. It is wanting in part of the duodenum. Of the muscular coats, the thinner external layer is formed of longitudinal fibres, while in the thicker, inner layer they are arranged circularly at right angles to the long axis of the tube. The submucous coat is a layer of loose substance of areolar tissue with fine elastic fibres, amdist which the blood-vessels ramify, and subdivide before entering the innermost or mucous coat.

The FUNCTION of the small intestine is, like that of the stomach, partly mechanical and partly solvent. The successive contractions, from before backwards, of its muscular walls tend to drive the contents towards the large intestine. Such motion is, like the similar movements of the fibres of the stomach, called *peristaltic action*. This form of movement is also spoken of as the *vermicular motion* of the intestine, and if the animal be suddenly killed, and its abdomen opened, the peristaltic action will be seen still taking place, and giving to the intestine an appearance as of so many crawling worms—whence the term "vermicular."

The process of digestion is further aided, as we shall hereafter see, by the products of the pancreas and liver, and also somewhat by the secretions of the crypts of Lieberkühn's and of Bruner's glands. The former secrete the *intestinal juice proper*, which is colourless, and seems to be a form of mucus.

The chyme of the stomach, having been modified by the action of all these secretions, changes into what is called *chyle*, the secretion

of the pancreas, and that of the liver, converting more of what remains of starch into sugar, dissolving more of what nitrogenous food has not been dissolved already, and making (by minute division and mixture) the oleaginous matters into an emulsion.

But one great office of the small intestine is the absorption of nutriment. This is already begun through the walls of the vessels of the stomach, but the villi of the intestine carry it on much more effectively. The most easily dissolved or transmissible fluid passes into the blood through the walls of the blood-vessels of the villi, while fatty and albuminoid matters find their way into the lacteals.

§ **16.** At the end of the small intestine, at its junction with the large, is a blind diverticulum or cul-de-sac, called the *cæcum*.

The LARGE INTESTINE is rather more than a quarter of the length of the small intestine (it is about a foot long), but it is considerably

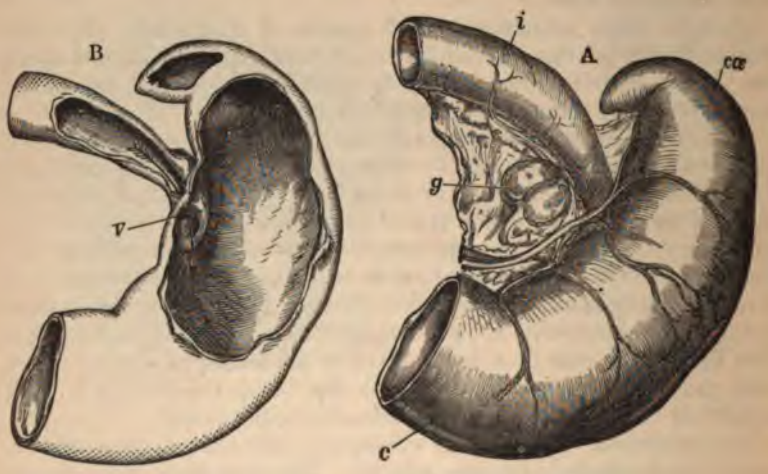


Fig. 95.—THE CÆCUM.

A. Seen externally.
B. Cut open.
cæ. Cæcum towards its apex.
g. Mesenteric glands.
i. Ileum.
v. Ilio-cæcal valve.

wider and tolerably uniform in width, tapering somewhat to its hinder end. Instead of being extremely convoluted, it forms but a single sweep forwards, transversely, and backwards. Its exterior exhibits a few slightly-indicated transverse depressions. It begins on the right side of the abdominal cavity, and passes forwards as what is called the *ascending colon;* it passes across to the left, on the posterior side of the stomach, as the *transverse colon*, and then turns backwards as the *descending colon*, ending in the terminal portion of the intestine called the *rectum*.

The CÆCUM may be said to be that part of the large intestine

which projects blindly (whence its name) beyond the point at which the small intestine opens into the ascending colon. It is a short, wide, simple, rather conical part, narrowing rapidly to its apex, but having its terminal portion more or less sharply bent towards the ileum, and separated off from the rest by a slight constriction—so that it forms a sort of appendix to the rest of the cæcum. This terminal portion is thick-walled and glandular, being lined by a sort of Peyer's patch. The entrance from the ileum into the cæcum is by a circular constriction (with its margin prolonged somewhat into the cæcum) called the *ileo-cæcal* valve.

There are many glands in the rather thick walls of the cæcum, especially towards its apex.

On each side of the hinder end of the intestine are two large secreting pouches, or ANAL GLANDS, each of which would contain a very large pea within its cavity. They are both embraced and invested by the external sphincter muscle, and are lined by glandular mucous membrane. Each gland opens externally just within the margin of the anus by a short duct, the inner end of which projects inwards into the cavity of the gland, of which it is the excretory channel.

The structure of the large intestine essentially resembles that of the small. It exhibits irregular internal folds in the descending colon, and in the rectum; and there are numerous follicles scattered throughout its whole extent, but its surface is not raised into processes or villi. There is thus a great contrast between its interior and the villous internal surface of the small intestine.

The FUNCTION of the large intestine is in great part mechanical. By its contractions its contents are driven onwards to the rectum, whence they are expelled by the contraction of the rectal walls and the simultaneous relaxation of the sphincter ani—the expulsive action being aided by the contraction of the muscular walls of the abdomen, and the backward pressure of the diaphragm. The power of absorption of this part of the alimentary tube is much less than that of the small intestine, as is evidenced by the absence of villi. Nevertheless it does possess a certain power of absorption, and it not improbably also serves to extract from the blood, and cast forth into the intestinal cavity, some substances, the removal of which is beneficial to the organism.

§ 17. The PANCREAS (Fig. 90, B) is a large, racemose gland, composed of, and entirely invested by, peritoneum. It consists of lobes and lobules of different sizes, connected together by areolar tissue, vessels and ducts, being in fact like the parotid gland, but somewhat looser in structure. In shape it is elongated and narrow, and is indistinctly divisible into two parts. One portion of it, *the body*, lies posterior to and above the posterior border of the stomach (enclosed between the layers of the posterior fold of the great omentum) on the right; the other and larger part, *the head*, passes backwards along the concave margin of the duodenum. It has two ducts; one of these joins the common bile-duct (from the liver)

before entering the intestine, and the other enters the duodenum, separately, an inch or more further backwards.*

The *function* of the pancreas is to secrete a special fluid, the pancreatic juice, which has in part the nature of saliva, inasmuch as it tends to convert starch into grape sugar. Unlike saliva, however, it has a powerful effect on albuminoid and gelatinoid matters, con-

Fig. 96.—CAT'S LIVER, VIEWED FROM BEHIND.

R. Right moiety of the liver.
L. Its left moiety.
c. Caudate lobe.
cf. Cystic notch.
d. Duodenum.
gb. Gall bladder.
lc. Left central lobe.
ll. Left lateral lobe.
lf. Left lateral fissure.
rc. Smaller portion of righ central lobe.
rl². Larger portion of right central lobe.
rl¹. Right lateral lobe.
rf. Right lateral fissure.
hv. Portal vein.
s. Spigelian lobe.
u. Umbilical fissure.
bd. Ductus communis choledochus.
o. Its opening into the duodenum.
p. Pylorus.

verting them, as the gastric juice does, into peptones. Besides these actions it also emulsifies fats.

§ **18**. The LIVER is the largest gland in the body, and lies mainly to the right, immediately behind the diaphragm, between it and the stomach, and protected by the cartilages of the ribs. Certain large

* In some cases a duct has been seen to lead, from the point of junction of the ducts above mentioned, to a small sac, serving to retain some of the secretion of the pancreas as the gall-bladder retains that of the liver.

blood-vessels (the aorta and vena cava) are interposed between it and the bodies of the vertebræ.

It is a solid organ, thick dorsally, and thinning out below; of a reddish-brown colour, smooth and convex towards the diaphragm, but concave and uneven on its opposite surface. It is divisible into certain parts, or *lobes*, which are defined and marked off, partly by grooves and notches in its substance, partly by ligaments and blood-vessels connected with it.

The liver is divided into two unequal lateral halves by a membranous ligament (the *broad* or *falciform ligament*), which passes to it from the adjacent surface of the diaphragm, and which consists of two folds of peritoneum, as will be hereafter explained. This ligament is attached to the liver in a line running from its dorsal margin to its ventral border; and the part on the right side of it is the larger.

When the posterior surface of the liver is in view, a deep notch (*u*) and groove may be observed opposite to, and corresponding with, the attachment of the broad ligament. This groove is called the longitudinal fissure, and it lodges a fibrous cord called the *round ligament*. The anterior part of this cord (which passes upwards to the liver from the navel) is the remnant of a structure temporarily developed in the very young condition—the umbilical vein—while the posterior part of the cord (which joins the vena cava) is the remnant of another primitive vessel—the ductus venosus.

On this account the ventral part of the groove is called the *umbilical fissure* (*u*), while its posterior part is named the *fissure of the ductus venosus*. This fissure then divides the liver into two unequal lobes on its hinder surface, and each of these is again subdivided by other fissures. Thus a small, prominent, undivided, somewhat pyramidal lobe (called *Spigelian*) is placed almost medially at the dorsal border of the liver (*s*), its apex extending outwards on the hinder surface of the left lateral lobe (*ll*). It is bounded on the right by a short deep groove called the *fissure of the vena cava*, because it is traversed by that vessel. The Spigelian lobe is bounded ventrally by the *transverse* or *portal fissure* which runs, almost at right angles, into the longitudinal fissure. It is into this transverse fissure that the portal vein, the hepatic artery and the great nerves enter, and it is from it that the main bile ducts proceed to convey away the biliary secretions.

The portal fissure runs to the right, beyond the limits of the Spigelian lobe. That part of the substance of the liver which is situate on the dorsal side of this outer part of the portal fissure, is called the caudate lobe (*c*). It is a moderate-sized, ridge-like lobe, which proceeds from the base of the Spigelian lobe to and along the hinder surface of the *right lateral* lobe (rl^1), and is more or less limited behind by the vena cava.

The right lateral lobe is small and separated from a much larger lobe, the *right central* (rl^2)—which lies next it but nearer the middle line—by a deep fissure called the *right lateral fissure* (*rf*). The

posterior surface of the right central lobe is marked by a depression in which lies a pear-shaped bag—completely invested by peritoneum—called the GALL-BLADDER, which has its blind end (or fundus) directed downwards near (*gb*), the ventral margin of the liver. The notch at which its fundus is situated, and the depression in which the bladder lies, is called the *cystic fissure* (*cf*). The fundus of the gall-bladder is occasionally buried in the liver's substance, and appears, through a cleft, in its convex surface. The part of the right central lobe which lies to the left of the gall-bladder (*rc*) is itself bounded on the left by the umbilical fissure already described.

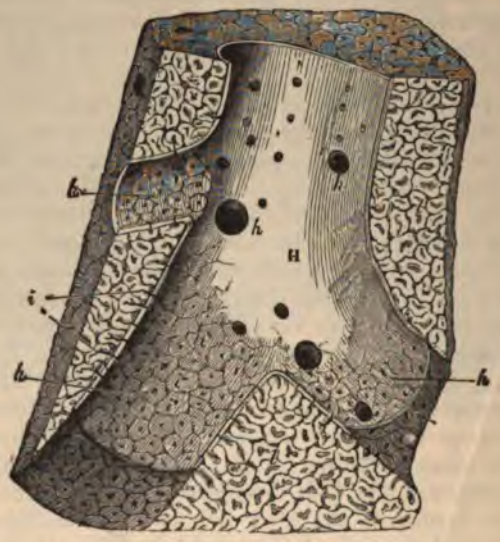


Fig. 97.—SECTION OF A PORTION OF THE LIVER (OF THE PIG), PASSING LONGITUDINALLY THROUGH A CONSIDERABLE HEPATIC VEIN, ENLARGED ABOUT FIVE DIAMETERS.

H. Hepatic venous trunk, against which the sides of the lobules are applied.
h, h, h. Three sub-lobular hepatic veins, on which the bases of the lobules rest, and through the coats of which they are seen as polygonal fissures.
i. Mouth of the intra-lobular veins, opening into the sub-lobular veins.
i'. Intra-lobular veins, shown passing up the centre of some divided lobules.
c, c. Walls of the hepatic venous canal, with the polygonal bases of the lobules.

Beyond it lies a very small lobe, the *left central lobe*, which is separated from a very large lobe—the *left lateral lobe* (*ll*)—by a deep fissure called the *left lateral fissure* (*lf*).

The bile, or *hepatic*, ducts issue from the lobes of the liver and the portal fissure, and join the duct which comes from the gall-bladder. The latter duct is called the *cystic duct*, and the common duct formed by its union with the hepatic ducts, is termed the *ductus communis choledochus* (*bd*). This opens into the duodenum at about an inch and a half from the pylorus—after being joined by one of the pancreatic ducts.

The cystic duct is convoluted, making about four turns, held together by areolar tissue.

The several hepatic ducts correspond with the different lobes of the liver, and are formed by the union of small ducts arising from the several liver (or hepatic) lobes. The ductus communis choledochus sensibly enlarges as it traverses the coats of the duodenum.

Fig. 98.—LONGITUDINAL SECTION OF A PORTAL CANAL, CONTAINING A PORTAL VEIN, HEPATIC ARTERY, AND HEPATIC DUCT, FROM THE PIG. ENLARGED ABOUT FIVE DIAMETERS.

P. Branch of vena portæ, situated in a portal canal, formed amongst the hepatic lobules of the liver.

pp. Larger branches of the portal vein, giving off smaller ones (*i i*), named inter-lobular veins; there are also seen within the large portal vein numerous orifices of inter-lobular veins arising directly from it.

a. Hepatic artery.

d. Biliary duct.

At *c c*, the venous wall has been partially removed.

The MINUTE STRUCTURE of the liver consists of a complex arrangement of microscopic blood-vessels and cells, connected by areolar tissue, as follows:—

When the substance of the liver is cut across, its solid substance presents a mottled appearance, and careful inspection shows that it is made up of a number of polygonal masses, which are called *lobules*. These lobules are seen to be arranged around a number of canals proceeding in two directions. One set of canals diverge from the portal fissure, and these are called *portal canals*. The other set of canals converge to the inferior vena cava, and these are called *hepatic veins*. Now, as will be hereafter seen, the blood is of two kinds, arterial and venous, and is respectively conveyed (except as regards the lungs,) by vessels called arteries and veins, accordingly as they carry the one or the other kind of blood. No less than three sets of vessels ramify in the substance of the liver, two sets conveying blood into, and one set (the hepatic veins) conveying blood out of it. Of the two sets of vessels conveying blood into it, one is arterial, the *hepatic artery*; the other is venous, the *portal vein*. These ramify in the portal canals along with branches of the hepatic ducts, the whole three sets of ramifications being surrounded and supported by areolar tissue, which is continuous with a fibrous membrane which invests the external surface of the liver generally. The several branches of the portal vein are much larger than the accompanying hepatic ducts, and these are somewhat larger than the arteries. The arteries convey nutriment to the framework of the liver, its branches ending in the walls of the ducts, blood-

vessels, and in the areolar tissue. The portal veins end by minute vessels, which surround and penetrate the lobules of the liver (whence they are called *interlobular veins*), while the hepatic ducts end in most delicate canals, which pass amongst the hepatic, or liver, cells, which make up the substance of the lobules between its multitudinous vessels.

The blood being thus conveyed to the circumference of each lobule, proceeds thence to its centre, where it collects in the commencements (ultimate twigs) of the hepatic vein which, from the fact that they thus take origin, are called *intra-lobular veins*.

The *liver cells* (or hepatic cells) form the secreting substance of the liver, and are spheroidal or polygonal nucleated bodies of a yellowish colour, containing granules and fatty matter besides the nuclei. They vary from $\frac{1}{800}$ to $\frac{1}{1050}$ of an inch in diameter.

The FUNCTION of the liver consists in the secretion of bile, though the full meaning and effect of its activity is not by any means entirely understood.

BILE is an alkaline, greenish-yellow, viscid, bitter fluid, containing from 8 to 16 per cent. of solid matter, consisting principally of a compound nitrogenous substance termed *bilin*. It also contains a non-nitrogenous substance called *cholesterin*, with certain salts and peculiar colouring matters (biliverdin and bilifulvin) containing iron. These colouring and other substances are formed by the cells of the liver, and do not pre-exist in the blood.

Another substance which is found accumulated in the liver after death, does not escape by the hepatic ducts. This is *glycogen* or animal starch.

The rapidity with which bile is secreted varies according to circumstances, increasing during the process of digestion.

The bile does not all pass directly into the intestine, but part of it regurgitates along the cystic duct into the gall-bladder, where it may remain for a certain time, and where it becomes somewhat thickened.

The action of the bile on the food is, in the first place, to neutralize the acid of the chyme, and secondly, to aid in emulsifying fatty matters.

But in addition to its effect on food, the secretion of bile is important as a mode of eliminating from the body substances, the removal of which is necessary to healthy life. The colouring matters of the bile are always entirely excreted, but other of its constituents appear to be decomposed in the large intestine, their nutritious matter being re-absorbed and their refuse driven on as *excretin*, *stercorin* and some other substances.

Yet other functions are performed by the bile, namely, that of exciting, directly or indirectly, the action of the intestinal mucous membrane and also the peristaltic action.

It is also said to have an anti-putrescent action on the food, putrefaction taking place in the alimentary canal in the absence of bile.

§ 19. The PERITONEUM is the large closed sac, formed of very delicate membrane, which both lines the abdominal cavity and coats its contents. It is one of a class of membranes called "serous," from the nature of the colourless fluid with which their surfaces are moistened, and which is more or less like the "serum" of the blood. Part of the membrane is applied to the inner surface of the walls of the abdominal cavity, and this is called its *parietal* portion, but it is every here and there reflected from the walls over the viscera contained within them, and such reflected parts are called its *visceral* or *reflected* portion. Thus the viscera nowhere enter into the real cavity of the peritoneal sac, while their movements can take place without friction because the moist inner surfaces of the peritoneum are everywhere juxtaposed, however complex and complete may be wrappings round which the viscera receive from the inflexions of this highly complex sac.

The membrane is formed of connective tissue, which is lined by a layer of squamous epithelial cells.

The layer of epithelium thus lining a serous cavity is called *endothelium*. The peritoneal serous membrane is attached to the parts to which it is applied by fibres of more or less loose areolar tissue.

The FORM OR ARRANGEMENT of the peritoneum is exceedingly complex, owing to the contorted and unsymmetrical arrangement of the viscera which it invests, and which fill the abdominal cavity In development, as will be hereafter seen, the alimentary canal is primitively an exceedingly simple tube traversing the abdominal cavity from before backwards. The peritoneum lining the ventral surface of the abdomen is continued upwards along its sides, nearly to the middle line, whence each lateral layer is reflected ventrally, to embrace closely each side of the alimentary tube, and to meet the reflection of the lateral layer of the other side, upon the ventral surface of the alimentary tube. Thus this tube is enclosed and *slung* in a fold of membrane, and really lies (as before said) external to the peritoneal cavity; though the two reflected folds (between the alimentary tube and the back of the abdominal cavity) become so closely applied together as to seem to form but one membrane.

As development proceeds, the alimentary tube becomes differentiated into regions of very different capacities; while, at the same time, it becomes enormously elongated, contorted, and unsymmetrically disposed, and so the membrane which holds it enclosed and attaches it to the dorsal wall of the abdominal cavity, becomes necessarily drawn out and folded in a very complex manner; and this complexity is increased by the fact that layers of the membrane which are primitively distinct grow together with contact, till they appear to be but one membrane.

Folds of the peritoneum which retain the primitive condition and still suspend portions of the alimentary canal from the mid-dorsal region of the abdominal cavity, are termed *mesenteries*; folds of peritoneum which pass from one viscus to another, are called

omenta; and folds which pass from the abdominal wall to viscera which do not form parts of the alimentary tube itself, are spoken of as *ligaments.*

The peritoneum forms a truly CLOSED SAC in the male, but in the female it has two small openings, which indirectly communicate with the external surface of the body. These openings are the mouths of the "Fallopian tubes."

Of the MESENTERIES, the mesentery *par excellence* is that which connects the small intestine with the dorsal abdominal wall, and conveys vessels to it. It contains numerous mesenteric glands (to be noticed hereafter in connexion with the lymphatic system) and vessels. Its vertebral border is very short, but its intestinal border is of course drawn out nearly to the length of the small intestine. Other folds attach the large intestine to the back of the abdominal wall, and are respectively called the *meso-colon* and *meso-rectum.*

The OMENTA are three in number, and the first and largest of these, the *great* or *gastro-colic omentum*, is really a modified mesentery, being an enormous extension of that membrane which primitively connected the stomach with the body-wall, and which is produced and folded on itself so as to form a great sac, constituting that apron-like fold which was before spoken of as covering the intestines when the abdominal cavity is laid open in front.

Anteriorly, the great omentum is attached to the stomach along its greater curvature; posteriorly, it is attached to the dorsal surface of the abdominal wall. Thus, this great omental sac consists really of four layers.

That it must do so is plain, since every mesentery consists of two layers (which hold between them the viscus they suspend), and, the great omentum being a pouch formed by the bulging out of a mesentery in a sac-like manner, each wall of the sac (being a part of a mesentery) must consist of two layers.

The second, *gastro-hepatic*, or *lesser omentum*, passes backwards from the hinder surface of the liver to the pyloric part of the stomach, and the beginning of the duodenum. Its two folds extend from the two sides of the portal fissure, and have between them the portal vein and hepatic artery, as well as the gall-duct.

The third, or *gastro-splenic omentum*, proceeds from the cardiac region of the stomach to the hilus of the spleen. There it divides, one layer passing all round the outer surface of the spleen, and returning to the other side of the hilus, whence the two layers proceed side by side to the diaphragm; forming what might be called a mesentery of the spleen. Between these layers the blood-vessels proceed to the spleen and to the stomach, showing that the gastro-splenic omentum is the remains of the proximal part of what was originally the gastric mesentery.

By the folding of the peritoneum upon itself with the development of the viscera, the edge of the gastro-hepatic omentum is brought so near the posterior abdominal wall that but a small space is left between. This space is called the *foramen of Winslow*, and the

inner surface of the great omental sac is continuous with its margins; and thus, through it alone, is a communication established between the cavity of that sac and the general abdominal peritoneal cavity.

The ligaments formed by folds of peritoneum, except those of the uterus (which will be noticed with the generative organs), are also three in number, all proceeding to the liver.

The first of these, the *falciform ligament* of the liver, is a double layer of peritoneum proceeding backwards from the hinder surface of the diaphragm and the abdominal wall down to the navel, to the anterior surface of the liver, where its line of attachment, as we have seen, divides that viscus into its right and left halves. From that line of attachment the two layers of the ligament separate and proceed right and left to invest the surface of the liver.

In the posterior, ventral free margin of the ligament (between the ventral abdominal wall and the liver) is a fibrous cord called the *round ligament*, and which is the relic of a fœtal structure. It extends from the navel to the longitudinal fissure on the hinder surface of the liver, as before described. The third ligament connects the dorsal border of the liver with the diaphragm.

Thus, the general INVESTING ARRANGEMENT of the peritoneum lines the interior abdominal wall, and invests the viscera, as follows:—It invests the liver, except where reflected from it; the hinder surface of the gall-bladder; the stomach (except the narrow line of attachment at each curvature); the spleen, except at its hilus; the ventral surface only of the pancreas and kidneys, and the anterior surface of the bladder. Almost all the small intestine, and more or less of the large intestine and rectum, are completely invested by peritoneum. Thus, these viscera are described as having a fourth or serous coat in addition to the muscular, areolar, and mucous coats already described.

CHAPTER VII.

THE CAT'S ORGANS OF CIRCULATION.

§ 1. The organs of circulation, or the *circulating* or *vascular** system, comprises all that great system of tubes (of very various sizes) which have already been referred to, as arteries and veins, and all the various channels, or vessels, by which the nutritive fluid of the body—the blood—is conveyed to and from every part of the cat's frame.

That it should be so conveyed is a manifest necessity of life, for since the process of nutrition takes place in the very innermost substance of the body (as has been already pointed out), there must be channels by which every part of the body may be supplied with its needed nutriment. Such nutriment is to be found in the blood, which has the power of repairing the waste of the tissues and supplying the materials for assimilation and growth, but which cannot obviously carry this power into effect except by moving from space to space throughout the body—without, that is, being propelled by "organs of circulation," and without exuding from the ultimate ramifications of such organs, to reach the very parenchyma itself.

But we shall see in the next chapter that processes of gaseous interchange, "respiration," and of the elimination of waste and other products, "secretion," also really take place in the innermost parenchyma, and not on the surfaces of the inner lining of the tubes of the various organs and internal cavities. Yet all that is so given out or exchanged must (if respiration and secretion are to be effected) find its way to such surfaces, and in order that it may be able so to do, we also require the aid of the circulating system. But the blood, in and by the very act of nourishing the various organs, must part with its nutritive material, and this, therefore, requires to be replenished if life is to be maintained. The needful gaseous matters are obtained by it in respiration; but the other matters have to be gathered from materials prepared for it within the alimentary canal. These materials, we have already seen, in part pass directly into the blood-vessels which surround that canal, and in part into the vessels

* A condition of *vascularity* (*i.e.*, the presence of blood-vessels) has already been attributed to certain tissues, such *e.g.* as the dermis, intestinal villi, &c.

called "lacteals," which are to be found in the intestinal villi. These lacteals we shall see open into tubes called "*lymphatic vessels*," or "*lymphatics*," and which vessels ultimately open and pour their contents into certain veins, after traversing—here and there in their course—certain bodies called *lymphatic glands*. The lymphatics do not contain "blood," but a colourless fluid called "*lymph*," consisting in part of the nutritious material absorbed from the walls of the alimentary canal, and partly of such of the colourless matter of the blood as has exuded from the vessels in order to effect nutrition, but has not been made use of. It is therefore taken up again by the lymphatics to be by them reconveyed to the blood-vessels. We have thus two nutritive fluids—"blood" and "lymph"—enclosed in two systems of vessels, "blood-vessels" and "lymphatics."

The *blood-vessels* form a system of tubes completely closed, save at the apertures where the lymphatics open in them. In part, the vessels are of microscopic dimensions, but in one place the system is dilated into a large, complexly formed, rhythmically contractile organ—the heart.

The heart may be considered as the central portion of the circulating system, all the other channels being subsidiary to it. These latter may be divided into three categories: (A) the vessels taking blood from the heart—which vessels are called *arteries;* (B) the vessels taking blood towards the heart—which are the *veins;* and (C) certain minute tubes which convey the blood to the tissues, and intervene between and connect the ends of the arteries and veins—the *capillaries.*

It may be well before proceeding to examine in detail these various parts, and those other parts which compose the lymphatic system, to consider the two fluids which these two sets of organs respectively convey.

§ 2. The BLOOD is a thickish alkaline fluid, somewhat heavier than water, which has a saltish taste and a faint odour, and is of a more or less scarlet or more or less purple red, according to circumstances. It consists mainly (more than 75 per cent.) of water, with a considerable quantity (12 to 14 per cent.) of an albuminoid substance termed hæmoglobin, the rest consisting of albumen and other protein matters and salts. A nitrogenous substance called fibrin may be obtained from fresh-drawn blood by whipping it with slender rods—the fibrin then adhering to the rods in the form of a soft, whitish, stringy matter. Though apparently homogeneous to the naked eye, blood spontaneously separates (when drawn from the body and allowed to stand undisturbed) into different parts—one fluid, the other more or less solid.

This process of solidification is called COAGULATION,* and it occurs thus: the fresh-drawn blood forms itself into a jelly-like mass,

* Fibrin, as such, does not exist in the blood. It is supposed by some to be formed by the chemical union of two albuminous substances, which exist side by side in the blood while alive.

but soon drops of clear fluid exude from it, and collect to form what is called the *serum*, while the solid mass left behind is the *clot*.

Sometimes the clot is of a lighter colour above than below, showing that the clot itself consists of two elements, as is indeed the case. The clear part of it, is that substance which it has been said may be obtained by whipping, namely, "fibrin;" while the red part, when examined by the microscope, is found to owe its colour to the presence of an immense multitude of minute coloured discoidal bodies called *corpuscles*,* and which may be seen to float freely about in quite fresh blood, or in blood which (from the addition of salt or some other suitable matter, or from being kept at a low temperature) is prevented from coagulating.

Thus fresh blood is found to consist of corpuscles floating in a fluid—the *liquor sanguinis*—which fluid yields both fibrin and serum. When coagulation takes place the fluid of the blood separates into two parts. One, the fibrin, solidifies, and, by entangling the corpuscles amongst its filaments, forms the clot, while the remaining part of the liquor sanguinis escapes as the serum.

The coloured, or RED CORPUSCLES are disc-like structures, only about the $\frac{1}{4400}$ of an inch in diameter, or even less. They are circular in outline, and each flattened side is concave and medianly depressed, so that each disc is thinnest from side to side in its middle, with a somewhat enlarged circumference.

These corpuscles have no limiting membrane, though their exterior is somewhat denser than their interior, and they are soft and elastic. They exhibit no interior structure and no nucleus, but they consist of hæmoglobin containing iron. Each is of a yellowish red colour, but by their excessive multitude they produce the deep red colour of the blood. In blood drawn from the body they tend to run together in strings, applying themselves face to face like piles of coins.

Besides the red corpuscles, the blood also contains a variable quantity of WHITE CORPUSCLES. These are much less numerous than are the red, there being only some two or three white to a thousand of the red, though the proportion increases after eating. They are also rather larger than are the red corpuscles; but their distinguishing characteristics (besides colourlessness) are their possession of a nucleus in their granular contents, and their spheroidal or irregular form. The white corpuscles, in fact, have the power of spontaneously, so to speak, altering their shape by protruding portions of their substance in an irregular manner and in all directions. This change of form is however effected very slowly, so that careful observation for several minutes, or several observations at intervals of about a minute, are needed to detect it. These movements are sometimes termed *amœboid*, from their resemblance to the movements exhibited by some of the lowest animals.

The blood, while within the body, during life, is really A TISSUE,

* Which make up about a third of the volume of the mass of the blood.

and as fully shares in the body's vitality as do the other tissues. The corpuscles may be regarded as answering to those nucleated cells which we have found to exist in the other tissues, while the liquor sanguinis corresponds with the matrix of such other tissues—the matrix being fluid in the blood tissue, instead of being calcareous, as is bone, chondrified as in cartilage, or more or less fibrous as in connective tissue.

As has been already mentioned, the blood may appear either scarlet or purple, and from the relation of blood so diversely coloured to the parts which contain it, these two kinds of blood are spoken of

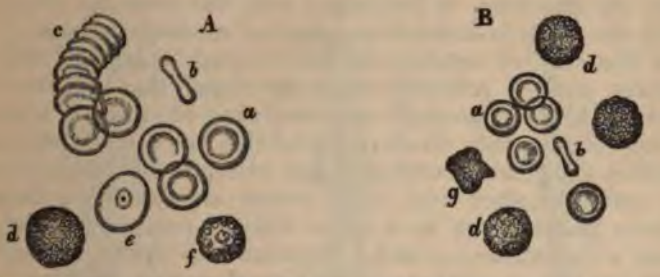


Fig. 99.—BLOOD CORPUSCLES OF MAN AND OF THE CAT, SIMILARLY ENLARGED.

A. Blood corpuscles of man.
B. Blood corpuscles of the cat.
a. Red corpuscles.
b. A single one seen edgeways.
c. A few grouped in a pile.
d. Normal white corpuscles.
e. A white corpuscle treated with acetic acid and showing its nucleus.
f. One slightly altered.
g. A white corpuscle in the act of changing its shape by amœbiform movement.

respectively as ARTERIAL and VENOUS. The scarlet or arterial blood is found (1) in the *arteries* or vessels which carry blood from the heart as well as (2) in vessels which proceed from the lungs. The purple or venous blood is found (1) in the *veins* generally, (2) in certain vessels ramifying in the liver, and (3) in others proceeding to the lungs.

The difference between arterial and venous blood depends upon arterial blood containing a greater quantity of oxygen, and venous blood possessing more carbonic acid. Blood contains a large amount of gas (about half its own volume), principally the gases just named, but also some nitrogen, introduced within it probably by the lungs.

§ 3. LYMPH is a slightly alkaline, clear, colourless, or pale yellow fluid, containing only 5 per cent., by weight, of solid constituents. It is thinner than blood, but, like it, contains albumen, some salts, and some extractive matters. It is devoid of red corpuscles, being in fact like the liquor sanguinis, and being, like it, capable of coagulation. It is in fact (as before said) made of the exudation of the liquor sanguinis mixed with fluid absorbed from the alimentary canal. Its likeness to blood is the more complete, since it contains numerous colourless corpuscles, "*lymph corpuscles*," and which are quite like the colourless corpuscles of the blood.

The blood and lymph are contained and conveyed on their cours by the various sets of vessels and other parts already enumerated about each of which there is much to be said.

§ 4. The ARTERIES are strong and very elastic tubes, so tha when empty they remain open and do not collapse. They ar lined internally with an epithelial layer, external to which is a laye of elastic tissue. External to this again is a stratum of organi muscular fibres, arranged in bundles placed mainly at right angle to the course of the artery and tending to surround it, though som fibres are longitudinal and others oblique in direction. Externa again to the muscular layer is a layer of elastic tissue (and elasti fibres are also more or less mixed with the muscular fibres), an finally the whole is enclosed by a layer of connective tissue.

In the smallest arteries the elastic coat is absent, while th muscular coat is relatively more developed than in the large arteries. Arteries, generally, run deeply in well protected situation As they advance they divide and subdivide into smaller and smalle branches. Different branches of the same, or of different trunk may unite together, and such unions are termed *anastomose* Arteries generally run in a rather straight manner, but they ma pursue a very tortuous course. Sometimes an artery may suddenl break up into a number of small anastomosing branches, whic reunite to form a single vessel. Such a network is called a *re mirabile*. The presence of the muscular coat enables the arteries t diminish their capacity by contracting their muscular fibres, or, b relaxing them, to enlarge it, since these fibres are contracted to certain moderate amount in the normal state of the arteries.* Th walls of the arteries are themselves supplied and nourished by minut vessels termed *vasa vasorum*.

§ 5. The VEINS are weak and thin-walled tubes, much less elast than the arteries—collapsing when emptied. They are lined in ternally with an epithelial layer, external to which is elastic tissu and a stratum of organic muscular fibres invested externally b connective tissue.

In some veins this muscular layer is absent, while it is excep tionally well developed in a large vessel going to the liver, th *portal vein*, and in that coming from the spleen. The veins ramif through the body, as do the arteries, but are more numerous an have greater capacity. They are arranged in a superficial an deep set—the deeper veins accompanying the corresponding arterie as what are called *venæ comites*. Veins anastomose together mor frequently than do arteries; their walls, like those of arteries, ar supplied with *vasa vasorum*.

The veins are generally furnished with certain structures no found in the arteries, namely, *valves*. These are crescentic folds o membrane, so arranged that in each the semilunar edge of the fol

* These muscles are under the control of special parts of the nervous system— the so-called *vaso-motor* and *vaso-dilat* nerves.

is continuous with the inner wall of the vein, while the straight edge of the fold hangs freely inwards into the cavity of the vein. Usually two such folds, or valves, are placed one opposite to the other, and when these hang down their free edges meet and so close altogether the passage through the vein. Any pressure exercised from that side towards which the concavities of the valves look, tends of course to separate them from the wall of the vein and so close the passage through it, while pressure from the opposite side tends to press the valves against the walls of the veins, and so to

Fig. 100.—DIAGRAMS, SHOWING VALVES OF VEINS.

A. Part of a vein cut longitudinally and opened out, showing two pairs of valves. On account of the vessel being thus opened out, each pair of valves appear as if placed side by side, instead of one opposite the other.

B. Longitudinal section of a vein, showing the two valves of a single pair in their natural position, and showing the apposition of the edges of the valves in their closed state. The slightest pressure applied from below would cause these valves to open; but pressure from above would only press them together more tightly.

C. Portion of a distended vein, seen externally and exhibiting a swelling in the situation of a pair of valves.

open the passage to its full width. Now these valves are so placed that their convexities look towards the capillary vessels, from which the vein which contains them springs, while their concavities look towards that point (generally the heart) towards which the stream of venous blood is flowing. Thus the action of these valves is to help on that stream along its course, since they readily yield and allow it to flow along its appointed direction, whilst they descend, unite, and bar the passage, when temporary local pressure or any other cause tends to drive the blood in the reverse direction to that which it ordinarily pursues.

There are no valves in the venæ cavæ, the portal and hepatic veins, those of the kidneys and uterus, nor in the pulmonary veins and those of the interior of the skull and vertebral column.

§ 6. The veins and arteries are, as has been said, connected together by the intervention of the sanguineous CAPILLARIES. These are microscopic vessels and form a network in most of the tissues—a network so rich that sometimes the interspaces between them are not wider than are the capillaries themselves. Their walls are extremely

delicate, and readily allow their contents to exude. It is only thus the unvascular tissues—such as dentine—are nourished. Besides the teeth, capillaries are absent from cartilage and from epidermal and epithelial structures.

The white corpuscles pass readily through the walls of the minute capillaries, but the red corpuscles do so but rarely. Both veins and arteries merge insensibly into capillary vessels, and a constant stream of blood passes from the latter to the former through them.

The smaller capillaries consist of a delicate membrane lined with endothelium; the larger ones have also a layer of organic muscular fibres.

§ **7.** The LYMPHATICS are present nearly everywhere in the body. They are smaller but more numerous than the veins, and anastomose more frequently. In some situations, as in the brain, they surround and enclose the blood-vessels, and they seem to take origin (as will be more fully pointed out when they are described,) in the mere interspaces between the elemental parts of different organs. When the lymphatics have advanced somewhat from their origin they possess three coats: namely, an inner one, of longitudinally disposed fibres of elastic tissue, lined with endothelium; a middle one, of circular, organic, muscular fibres, mixed with elastic fibres and an outer coat of connective tissue—also with a few elastic fibres.

Like the blood-vessels, the lymphatics have *vasa vasorum* in their walls.

Valves, like those of the veins, exist in the lymphatics and lacteals. They are distributed at shorter intervals, and their structure is sometimes less regular.

The lymphatics and lacteals in their course pass (as has been already observed,) through certain structures called LYMPHATIC GLANDS. These are rounded bodies, consisting mainly of a mass of lymph corpuscles enclosed in a firm envelope and richly supplied with blood-vessels and lymphatics. Each gland is coated externally by connective tissue (which may contain muscular fibre cells,) and which completely invests it, save where the vessels enter and leave it. This fibrous coat sends in processes, called trabeculæ, into the substance of the gland, which substance—the proper glandular substance—consists of a mass of lymph corpuscles, with connective tissue. The outer part of this mass (the cortical substance,) is generally enclosed in a number of chambers, *alveoli*, while the more central part (the medullary substance) is enclosed—like so many cords—between the meshes of the trabeculæ. In these chambers thus containing masses of lymph corpuscles, a certain space is left, called the *lymph sinus* or lymph-channel, which space is crossed only by fibres of connective tissue, with their nuclei, and is traversed by the lymph stream. The lymphatics which come to the gland—the *afferent lymphatics*—lose all their coats as they enter, save the epithelial lining, which is continued on over the trabeculæ. Similarly the lymphatics which leave the gland—the *efferent lymphatics*

—begin to arise from the epithelial investment of the trabeculæ, and only acquire their coats, other than epithelial, as they leave the gland. Thus a lymphatic gland is, as it were, an expanded sinus into which a number of lymphatics merge, and wherein it appears a multiplication of lymph corpuscles takes place, probably by spontaneous division—the parts of the corpuscles thus spontaneously dividing growing up into whole corpuscles.

Each gland is richly supplied with blood-vessels, and the lymph

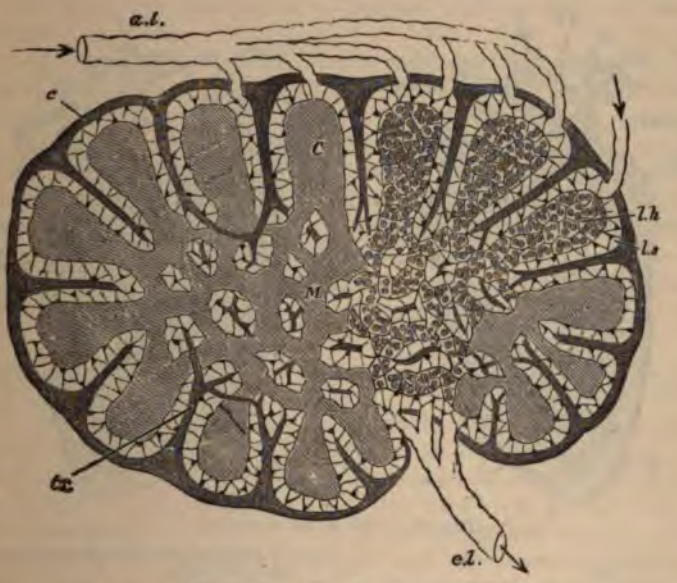


Fig. 101.—DIAGRAMMATIC SECTION OF A LYMPHATIC GLAND.

al. Afferent lymphatics.
el. Efferent lymphatics.
c. Cortical substance
m. Medullary substance.
ls. Lymph sinus.
c. Fibrous coat.
tr. Trabeculæ.
Lh. Lymph corpuscles.
The letter *C* is placed in one of the alveoli. The trabeculæ are represented by a dark shade, and are seen extending inwards from the fibrous coat and as spots in the medullary substance—such spots being trabeculæ cut across. At the upper right-hand part of the figure the lymph corpuscles, *Lh*, are represented in three alveoli and in the adjacent medullary part. Elsewhere they are not represented. A whit band is to be seen around all the alveoli, nd also round each of the cut-across trabeculæ in medullary substance. The band is the lymph sinus, a d the irregular lines which cross it at short intervals are the connective tissue fibres and nuclei.

which leaves it is not only richer in colourless corpuscles than is that which comes to it, but also in fibrin. These glands are conspicuous in the neck, the axilla, and the thigh, and speedily enlarge in size when any part of the body near them becomes the seat of pain.

§ 8. The HEART is a thick muscular and hollow organ, from the anterior, broad part of which great blood-vessels originate.

It is enclosed in a sac of fibrous tissue lined with epithelium, called the *pericardium*. It consists of four chambers, two of which

are called *auricles*, and the other two, *ventricles*—one of each on each side. The auricle and ventricle of the right side are completely divided off from those of the left side. The auricles open into the ventricles by valvular apertures, and valves guard the openings of the great vessels.

Such being a summary of its main characters, its various parts need examination in detail.

The heart of the cat lies on the ventral side of the body, within

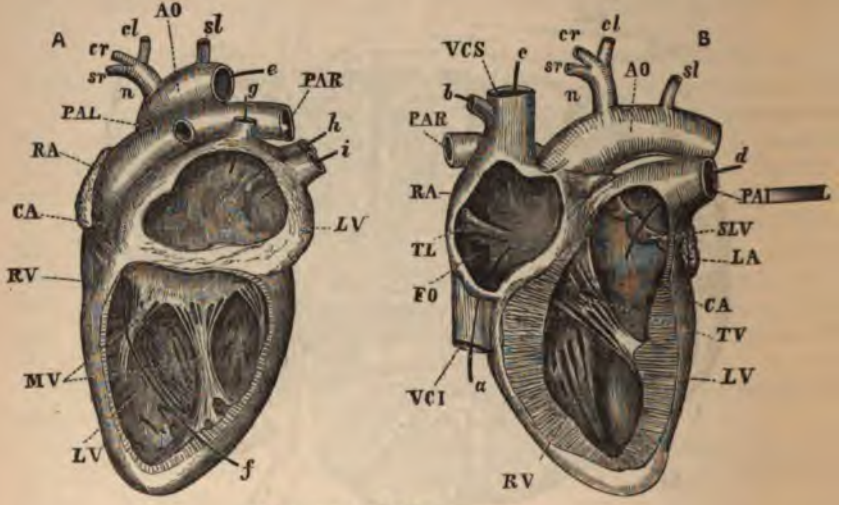


Fig. 102.—CAT'S HEART CUT OPEN.

A. The left side.
B. The right side.
a. Style passing up through inferior vena cava to right auricle.
AO. Aorta.
b. Style passing down from the vena azygos through superior vena cava into right auricle.
c. Style passing down from the superior vena cava into the right auricle.
CA. Conus arteriosus.
cl. Left carotid.
cr. Right carotid.
d. Style passing from conus arteriosus into left branch of pulmonary artery.
ef. Style passing up from left ventricle into aorta.
FO. Place where the foramen ovale existed in the fœtus.
g, *h*, *i*. Styles passing through pulmonary vei into left auricle.
LA. Left auricle.
LV. Left ventricle.
MV. Mitral valve.
n. Innominate artery.
PAL. Left branch of pulmonary artery.
PAR. Right branch of pulmonary artery.
RA. Righ auricle.
RV. Right ventricle.
sl. Left sub-clavian artery.
SLV. Semi-lunar valve.
sr. Right sub-clavian artery.
TL. Tubercle of Lower.
VCI. Inferior vena cava.
VCS. Superior vena cava.

the thorax, upon the inner surface of the sternum and between the two lungs. It is almost globular in shape, but slightly narrows towards its posterior end or *apex*, which touches the anterior surface of the diaphragm.

At its opposite end, or *base*, the heart is connected with several great blood-vessels, but elsewhere its surface is free.

The *pericardium* is a bag of dense fibrous tissue with an epithelial lining, and contains—like the peritoneum—a serous fluid. This

bag, the fibres of which interlace in all directions, adheres posteriorly to the anterior surface of the central tendon of the diaphragm, while anteriorly, it is attached to the outer coats of the great vessels which proceed to and from the heart, and is prolonged for some distance along their course. The internal, or serous, lining of the pericardium is (after lining the fibrous part forwards to its attachments) reflected back upon the outer surfaces of the great vessels just referred to, and closely invests the immediate outer surface of the heart, which is thus (like the roots of the great vessels) invested both by two layers of serous, and by one of fibrous membrane.

The external surface of the heart indicates its *composition*, since two longitudinal furrows indicate the separation of the heart into a right and left half, while a transverse furrow indicates the separation of each half of the heart into an anterior and a posterior portion. The anterior portion of each half is an *auricle*, and the posterior portion of each half is a *ventricle*. The auricular part of the heart (the two dorsal portions) is thin-walled and soft, and each portion bears a small appendage something like an animal's ear—whence the name "auricle." The two auricular appendages (one for each auricle) appear conspicuously on the anterior part of the heart. (See Fig. 104, *RA* and *LA*.) The ventricular part of the heart (the two ventricular portions) is thick-walled, firm and slightly conical from before backwards.

§ 9. GREAT BLOOD-VESSELS are connected with the anterior part of the heart as follows:—The anterior part of the heart is conspicuously distinguished by two large arterial trunks proceeding from it contiguously, whereof the smaller and more dorsally situated arches backwards and to the left over the right-hand branch of the two branches into which the larger and more anteriorly situated trunk divides. This more ventrally situated trunk proceeds obviously from the right ventricle, it is the *pulmonary artery*, and its two branches just referred to go respectively to the right and left lung. The deeper or more dorsal trunk is the *aorta*, and a little further examination will show that it proceeds from the left ventricle. If now the heart be turned round, a large vein will be seen proceeding forwards to it on what is naturally the right side of the descending continuation of the arch of the great aorta. This vein is the *vena cava inferior*, and opposite to it—proceeding backwards to the heart from the front part of the body—is another vein, the *vena cava superior*, which passes backwards on the ventral side (the heart being in its natural position,) of the right branch of the pulmonary artery. These two great veins proceed to the right auricle. Other smaller veins (two on each side) are seen proceeding more or less horizontally inwards to the heart. These are the *pulmonary* veins, and they go to the left auricle.

§ 10. The HEART is divided internally into four cavities corresponding with the four-fold division already noticed.

The whole inner wall of the heart is lined with a layer of endothelium, which immediately invests a network of elastic fibres.

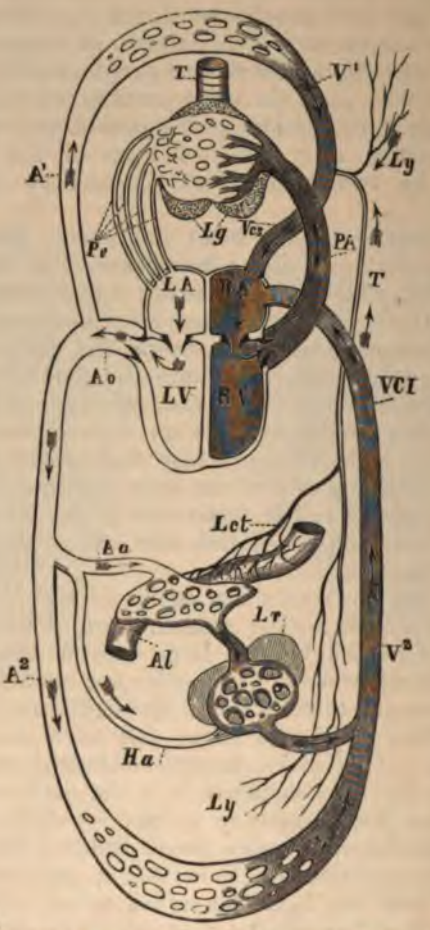


Fig. 103.—Diagram of the Course of the Circulation, seen dorsally.

Aa. Arteries to alimentary tube.
A¹. Arteries to anterior parts of body and fore-limbs.
A². Arteries to hinder parts of body and hind-limbs.
Al. Alimentary tube.
Ao. Aorta.
Ha. Hepatic artery.
Hv. Hepatic vein.
Lct. Lacteals.
Lg. Lungs.
LA. Left auricle.
Lr. Liver.
LV. Left ventricle
Ly. Lymphatics.
PA. Pulmonary artery.
PV. Pulmonary vein.
RA. Right auricle.
RV. Right ventricle.
T. Thoracic duct.
V¹. Veins from anterior parts of body and fore-limbs.
V². Veins from posterior part of body and hind-limbs.
VCI. Vena cava inferior.
VCS. Vena cava superior.
VP. Vena porta.
The vessels which carry venous blood are distinguished by shading. Arrows indicate course of the blood-lymph and chyle.

Thus the substance of the heart shows a similarity of structure that of the vessels which might be expected, since its walls

ectly continuous with the walls of the arteries and veins which en into it. The muscular fibres, however, of which the heart composed are very numerous, forming a thick mass, and they are the striated kind and of a deep red colour. Individually, never-eless, they are smaller than the ordinary striated fibres. They are o devoid of sarcolemma, and they often branch and anastomose. The fibres are arranged in layers disposed in various spiral curves ound the cavities of the heart. The muscular walls of the ventricles e thicker than those of the auricles, and that of the left ventricle again thicker than that of the right ventricle. Blood-vessels, rves and lymphatics, with fat and areolar tissue, enter into the com-sition of the heart, and fibrous and fibro-cartilaginous structures play portant parts in its composition in connection with certain valves.

These substances are so arranged that (as already remarked) a mplete partition is formed between the right and left sides of the eart; a septum entirely separating the cavities of the two auricles nd the two ventricles respectively. Thus there is no direct mmunication between the ventricles, or between the auricles.

The cavity of the right auricle however communicates not only th the interior of the venæ cavæ which open into it, but also th that of the right ventricle, this latter opening being called the ht auriculo-ventricular aperture. Besides this communication th the right auricle, the right ventricle only opens into the lmonary artery. Similarly the cavity of the left ventricle com-unicates not only with the interior of the pulmonary veins which en into it, but also with that of the left ventricle, this latter ening being called the left auriculo-ventricular aperture. Besides s communication with the left auricle, the left ventricle only ens into the aorta.

§ 11. The COURSE OF THE BLOOD THROUGH THE HEART is as lows:—Venous blood is brought back by two large veins (the *æ cavæ*) from all parts of the body to the right auricle, whence it oceeds to the right ventricle. From the right ventricle it is rried to the lungs by the pulmonary artery and brought back m the lungs by the pulmonary veins to the left auricle; from ence it proceeds to the left ventricle which distributes it, by e aorta, over every part of the body.

Thus the blood, in its course to and from the heart, performs two fferent circuits. On the one hand, the whole of the blood passes m the right ventricle, through the lungs, and back to the left ricle, thus performing what is called the *pulmonary circulation*. a the other hand, the whole of the blood passes from the left ntricle all over the body, and thence back to the right auricle, us performing what is called the *systemic circulation*.

It is while passing through the lungs that the blood undergoes at process of gaseous interchange which makes it acquire a bright arlet colour—the colour of normal arterial blood. On its way to e lungs it is of a deep purple tint—the colour of normal venous ood. Thus it comes about that the vessels which carry the blood

from the lungs to the heart carry bright scarlet or arterial blood, although they (inasmuch as they are vessels conveying blood towards the heart) are called "veins"—the pulmonary veins. Similarly, the vessels which carry the blood from the heart to the lungs contain dark purple or venous blood, although they (inasmuch as they are vessels conveying blood from the heart) are called "arteries"—the pulmonary arteries.

§ **12.** The current of the blood through the heart is kept up by the alternate contraction and dilatation of its four chambers, which is brought about by the successive contraction and relaxation of its various sets of muscular fibres. Its *course through the heart* is, however, determined by the action of certain VALVES which guard its most important apertures, and which, by acting like the valves of the veins, readily allow the blood to pass in one direction, while they oppose an effectual barrier to its passage in the opposite direction. The valves which most resemble those of the veins are the valves which are placed at the root of the aorta and pulmonary artery. These are called *semilunar valves*, and there are three in each vessel. They consist of processes of fibrous tissue (invested with endothelium), and each is continuous by one curved edge with the wall of the artery, while the other edge hangs freely so far out from the wall of the vessel that the whole three valves, when so hanging, meet together (by a tri-radiate suture), and form a complete partition across the vessel. The margin of each valve is strengthened by a tendinous band, and at its middle is a small fibro-cartilaginous nodule called a *corpus Aurantii*.

While the blood is flowing from the contracting ventricles, these valves lie back against the inner walls of the arteries, but when the ventricles dilate and the elasticity of the arterial walls tends to drive the blood back into the ventricles, these valves immediately descend, and the greater the pressure from above, the more completely and accurately do they close together.

At the roots of the pulmonary veins there are no valves, and there is only a rudimentary one at the root of the venæ cavæ. At each of the auriculo-ventricular openings, however, there is a valve of complex structure, consisting of membranous flaps, with delicate tendinous cords (*chordæ tendineæ*) attaching them to papillary prolongations inwards—*columnæ carneæ*—of the muscular ventricular walls.

The valve of the right auriculo-ventricular aperture is called the *tri-cuspid valve*, because it consists of three segments. The delicate tendinous cords above named proceed partly from the walls of the ventricle (especially the septum), but mainly from little muscular prominences—the columnæ carneæ. The tendinous cords are so distributed that some of those from each origin proceed to the edge of one valve, while the others proceed to the adjacent edge of another valve—thus diverging as they advance (Fig. 102, B).

The valve of the left auriculo-ventricular aperture is called the *bi-cuspid* or *mitral valve*, and consists but of two segments. It is

much thicker and stronger than the tri-cuspid valve, but its essential arrangement is the same.

The action of the tri- and bi-cuspid valves is similar, and is inverse to that of the semi-lunar valves. When the auricles contract and the blood tends to flow into the ventricles, these valvular flaps readily bend backwards and allow it free passage; but when, by the contraction of the ventricles, the blood tends to be driven into the auricles as well as into the great arteries, then these valves immediately close, and are pressed towards the auricles, while they are prevented from going too far (and so being driven into the auricles) by the numerous chordæ tendineæ which hold them firmly attached, as the cords of a tent hold and sustain it. The exactness with which they meet together is rendered complete by the *columnæ carneæ* themselves, which participate in the contraction of the cavity from the walls of which they proceed.

§ 13. The RIGHT AURICLE (Fig. 102, B, *RA*) is situated at the ventral side of the base of the heart, and has a smooth surface. The superior vena cava (which is very short) opens into the anterior portion of this chamber, and the inferior vena cava opens by a larger opening into its posterior part—above the auriculo-ventricular aperture—while between them is the orifice of a small vein called *coronary*, which brings back the blood from the walls of the heart itself. This part of the cavity (as distinguished from the cavity of the auricular appendage) is called the *sinus venosus*. At the hinder part of the septum, which divides this auricle from the left one, is an oval depression called the *fossa ovalis* (*FO*), which is the indication of a fœtal condition, for, as we shall see, in the embryo an opening leads directly from one auricle to the other. Immediately in front of this is a marked transverse prominence called the tubercle of Lower (*TL*).

The LEFT AURICLE, which, when distended, has a somewhat quadrangular appearance, lies to the left on the dorsal aspect of the base of the heart. The openings into it of the pulmonary veins are dorsally placed, and there are usually two on each side. Those of the right side, however, meet together close to the auricle, so that there seems to be but one pulmonary vein opening into it on that side. The wall of the septum shows a slight depression, corresponding with the fossa ovalis of the right auricle.

The RIGHT VENTRICLE forms the right side of the ventral aspect of the heart from the transverse furrow onwards towards its apex. Internally it presents the valvular structure (the tri-cuspid valve) already described, but its upper and anterior part is smooth and free from columnæ carneæ. It is also prolonged forwards in a conical manner, whence this part has been named the *conus arteriosus* (*CA*). The left wall of the ventricle is convex, the septum between the ventricles so bulging into its cavity as to make that cavity appear crescentic when the right ventricle is transversely bisected. The muscular wall of this chamber is much thicker than that of either of the auricles. The opening (with its semi-lunar

valves) which leads into the pulmonary artery is remote from the auriculo-ventricular opening.

The LEFT VENTRICLE, by far the thickest-walled portion of the heart, extends backwards to its apex mainly on the posterior aspect of the organ. The side which is formed by the septum is concave instead of convex—the transverse section of the cavity of the ventricle being oval. The opening (with its semilunar valves) which leads into the aorta is close beside the auriculo-ventricular opening, but to the right, and somewhat ventrally to the latter.

The *coronary arteries*, which convey the blood for the nutrition of the substance of the heart, do not lead from the cavity of the ventricle itself, but from the aorta (one opening on each side) immediately in front of the attachment to it of its semi-lunar valves.

§ **14.** All the ARTERIES of the body, with the exception of the pulmonary artery and its branches, are larger or smaller ramifications of that great artery, called the aorta; and all without exception therefore, are ramifications of vessels which proceed directly from one or other of the ventricles of the heart. Those which proceed from its right side, are the arteries of the pulmonic circulation and carry venous blood; those which proceed from its left side, are arteries of the systemic circulation, and carry arterial blood.

The PULMONARY ARTERY is the most capacious vascular trunk in the body, but is very short. Arising from the conus arteriosus, it passes dorsally and to the left, and then bifurcates. One branch passes to the right, above the arch of the aorta. It then divides and sub-divides within the right lung. The other branch passes to the left, beneath the dorsally and posteriorly-extending part of the aortic arch, and then divides and sub-divides within the left lung. Each pulmonary artery, at the root of the lung, lies dorsally to the pulmonary veins, and ventrally to the air-tube or division of the windpipe, which there enters the lungs. A little to the left of its bifurcation, the pulmonary artery is connected by a fibrous band with the concavity of the aortic arch. This band is the relic of a fœtal tubular structure, which in the embryo places the cavities of these two great arteries in direct communication, and is then called the *ductus arteriosus* (Fig. 104, *da*).

§ **15.** The AORTA springs from the base of the heart, rather dorsally to the pulmonary artery and between the anterior ends of the two auriculo-ventricular apertures. It arches to the left, over the right branch of the pulmonary artery, and over the root of the left lung, till it reaches the front—*i.e.*, the ventral side of the vertebral column. Thence it passes backwards through the hinder margin of the diaphragm, and ends by dividing into the iliac arteries, which go to the pelvic viscera and pelvic limbs.

The aorta is, as it were, the axis of the systemic arterial system, and (apart from small branches and large vessels given off to the abdominal viscera) may be said to give off eight branches or sub-divisions, four being anterior and four posterior. Of the four anterior branches, one goes to each pectoral limb and one to each

e of the head. The four posterior branches are the iliac eries already referred to. Besides the *aortic arch*, the rest of its rse, which is called the *descending aorta*, is sub-divided into the rt in front of the diaphragm and the part below it—*i.e.*, into the *racic* and the *abdominal* aorta.

The *arch of the aorta* gives off, almost from its very starting int—as before mentioned—the *coronary* arteries (which go to e heart itself), and afterwards the four great vessels (which

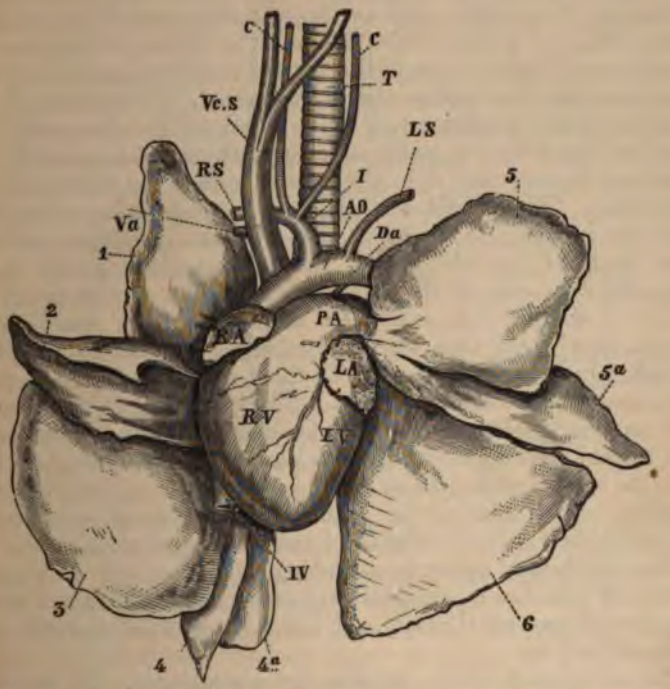


Fig. 104.—THE HEART, GREAT VESSELS AND LUNGS OF THE CAT; VENTRAL ASPECT.

Ao. Arch of aorta.
CC. Carotid arteries.
Da. Ductus arteriosus.
LA. Left auricle.
LV. Left ventricle.
PA. Pulmonary artery.
RA. Right auricle.
RV. Right ventricle.
T. Trachea.
IV. Vena cava inferior.
VS. Vena cava superior.
Vc. S. Vena azygos.
1. Upper lobe of right lung.
2. Second lobe of right lung.
3. Third lobe of right lung.
4. Fourth or lowest lobe of right lung.
4a. Partly separate portion of fourth lobe.
5. Upper lobe of left lung.
5a. Partly separate portion of the same.
6. Lower lobe of lef. lung.

to the head and fore-limbs) by two very unequal trunks. One of se, the larger, and placed on the right, is called the *innominate ery.* (Fig. 102, *n.*) It soon gives off a large branch (*cl*), which is *left carotid* artery; and the remaining part, almost immediately urcates into the *right carotid* and the *right sub-clavian* arteries.

The second and much smaller vessel given off from the arch of the aorta, is the root artery of the arteries of the left fore-limb—*i.e.*, is the left sub-clavian artery (*sl*). After giving this off, the aorta passes upwards as the thoracic part of the *great dorsal* (in man, the "descending") *aorta*. It gives off a number of branches, which will be referred to shortly.

§ **16**. The two CAROTID ARTERIES pass forwards along the neck, one on the right and the other on the left side of the trachea and œsophagus, to the head. Each gives off in succession the following branches:—Each gives off a rather large artery to supply the muscles of the side of the neck; and, opposite to this, a small branch to the lymphatic gland lying on the middle of the trachea. Next comes the *thyroid* artery, which goes to the thyroid cartilage, and to a structure to be hereafter described as the thyroid gland. It then gives off (from its opposite side) another artery to the muscles of the neck, and (almost opposite this) a very large *lingual* artery, which passes dorsally to the basi-hyal, beneath the stylo-glossus, and goes to the under surface of the tongue. The carotid next gives off a small *facial artery*, which sends out branches to the cheek, and ends in the upper and lower lips. A small branch goes to the sub-maxillary gland, starting from the very root of the facial artery. The carotid artery then makes a sharp bend, and gives off backwards a branch to the parotid gland; and then, at the further end of the curve, another branch, which also goes in part to the parotid gland, and a part to the muscles of the temporal fossa. This arched part of the carotid ends anteriorly, close to the anterior margin of the glenoid surface. The carotid then breaks up into a plexus of minute branches, which run side by side under the eye-ball, and over the orbital plate of the maxilla. From this plexus minute arteries are given off, such as the ophthalmic, ciliary, ethmoidal and meningeal arteries.

The *ophthalmic* artery passes along the inner side of the orbit, giving off branches to the lachrymal gland, the forehead and muzzle, the eye-ball and nasal cavity, the latter being called the *ciliary* and *ethmoidal arteries*.

The *meningeal artery* supplies the dura mater. It enters the skull from the plexus, through the sphenoidal fissure.

The *nasal artery* is a small branch which passes through the spheno-palatine foramen (in company with the nasal nerve), and continues on, skirting the nasal septum.

The carotid also gives off the *superior dental artery*, which enters the maxilla posteriorly, and supplies the upper teeth. Finally, the carotid passes through the infra-orbital foramen, and terminates as the *infra-orbital artery*, which distributes its branches about the face.

A very minute vessel, called the *internal carotid*, is given off from the main carotid in the vicinity of the foramen lacerum posterius. It enters that aperture, and passes along a slender canal between the basi-occipital and basi-sphenoid, and the adjacent part of the temporal bone. It then enters the cranial cavity on the

inner side of the anterior end of the petrous part of the temporal bone, and unites with the circle of Willis, formed by the branches of the basilar artery The internal carotid artery is so minute that it would not be worthy of note were it not for its large size in man and many other animals.

§ 17 The SUBCLAVIAN ARTERY is the root artery of the fore-limb. That of the right fore-limb springs from the larger branch of the innominate artery. That of the left fore-limb takes origin directly from the arch of the aorta.

The subclavian artery first approaches the clavicle, and then, arching over the first rib, recedes to the axilla and becomes the axillary artery.

The first branch given off by the subclavian is the *vertebral artery*. It bends rather sharply upwards to pierce the transverse process of the sixth cervical vertebra. It then advances through the perforations of the other cervical transverse processes, till, having traversed that of the axis, it bends at a right angle to reach the notch between the transverse process and the anterior articular process of the same bone. It then traverses the atlas, and, finally, entering the cranium through the foramen magnum, it unites (on the upper surface of the basi-occipital) with its fellow of the opposite side to form the basilar artery.

The *basilar artery* runs forwards as a long single vessel, gives off a branch on each side, and then continues on to form a circular vessel around the infundibulum and pituitary body in its sella turcica. This circular vessel is the *circle of Willis*, already mentioned; the internal carotids unite with it, and branches to the brain are given off anteriorly and laterally from it.

The second branch given off from the subclavian on the same side as the vertebral, is the *thyroid axis*. It arises covered in by the scalenus muscle, and arches forwards and upwards over the scapula—sending a branch up to the thyroid body.

A considerable vessel, the *internal mammary artery*, is given off directly opposite to the thyroid axis. It passes backwards along the inside (dorsal surface) of the cartilages of the ribs. It gives off a long and very slender branch, called the *superior phrenic*, which passes backwards to the diaphragm between the lung-root and the pericardium.

The *superior intercostal artery*, extends along the inside of the first three ribs, supplying the intercostal muscles. About half-an-inch beyond the origin of the thyroid axis a second artery is given off, which arches forwards and upwards over the scapula.

§ 18. The subclavian becomes the AXILLARY ARTERY as it passes into the axilla, between the pectoralis, subscapular, and latissimus dorsi muscles, surrounded by the nerves of the brachial plexus. It gives off various branches, as follows: the *superior thoracic*, which goes to the pectoral muscle; the *acromial thoracic*, which is large and divides into advancing and receding branches which respectively supply the deltoid, pectoralis and serratus magnus muscles; the *long thoracic*

and *alar-thoracic arteries*, which go respectively to the thoraci muscles and axillary lymphatic glands; finally, the *anterior* an *posterior circumflex* arteries (the latter being very large) which pas round and embrace the uppermost portion of the humerus.

Below the axilla the axillary artery takes the name of *brachia* and descends to the elbow between the biceps, the coraco-brachiali and the brachialis anticus muscles. It gives off a branch called th *superior profunda* artery, which accompanies the muscular spir nerve and winds round the back of the humerus to its outer lowe part. Another branch, the *inferior profunda* artery, is given o lower down, and passes to the inner side of the lower part of th arm—in company with the ulnar nerve. Having passed throug the internal condyloid foramen and reached the concavity of th elbow, the brachial artery divides into two branches, called th radial and ulnar arteries.

The *ulnar artery* (which is much smaller than the radial) passe along on the ulnar side of the flexor surface of the fore-arm (beneat the pronator teres, flexor carpi radialis, palmaris longus, and flexo sublimis muscles) into the palm, when it joins a branch of the radi artery to form a loop called the *palmar arch*.

Soon after its origin the ulnar artery gives off a branch calle the *interosseous* artery, which descends along the anterior surfac of the interosseous membrane.

The *radial artery* continues on the line of the brachial artery and extends along the flexor aspect of the radius to the wrist, whe it turns to the dorsal surface of the fore-paw and then penetrate between the second and third metacarpal bones, and unites with branch of the ulnar artery to form a *palmar arch*. The radial arter is more superficial than the ulnar, being only overlapped by th supinator longus muscle. The palmar arch gives off a very sma artery to the pollex and larger ones, which subdivide and go to th four other digits.

§ 19. The THORACIC AORTA passes backwards to the left an ventral side of the vertebral column extending to the diaphragm after perforating which it becomes the abdominal aorta. It lies i the posterior mediastinum (or dorsal space between the lung beside the œsophagus. It gives off many small arteries, such as th bronchial arteries (to nourish the lungs and the air-tubes), those the œsophagus and *intercostal arteries*, which supply those intercosta spaces which are not supplied by the intercostal branch of the sub clavian. Each intercostal artery passes along the posterior margi of a rib on the deep surface of the external intercostal muscle. Th vessels of the right side have, of course, to cross transversely th ventral surface of the vertebral column. Each intercostal also give off a small *posterior* or *dorsal* branch, which ascends, inside the ante rior costo-transverse ligament, to the muscles of the back. The tw hindmost intercostals on each side are rather lumbar than dorsa arteries, since they traverse the trunk behind the last rib.

The ABDOMINAL AORTA is the continuation backwards, beyond th

diaphragm, of the thoracic aorta. It gives off certain noteworthy branches—the inferior phrenic, lumbar, cœliac, mesenteric, supra-renal, renal, and spermatic (or ovarian) arteries—and then ends by dividing into five parts, namely, its really posterior termination, the *caudal*, or inferior sacral, artery, and the two internal and two external iliac arteries.

The *inferior phrenic*, which is exceedingly small, goes to the hinder surface of the diaphragm, and gives off a branch which extends along the psoas. The *lumbar arteries* continue on backwards, the series of intercostals quite resembling the last two of the latter, which go to the lumbar region. They also give off a *dorsal branch*, which passes upwards between the transverse processes of the vertebræ. The main trunk of each runs down amidst the abdominal muscles, which it supplies. The *cœliac* artery, or *cœliac axis*, is a short and wide vessel which arises close to the diaphragm, and quickly divides into three important visceral branches:

A. The first of these is the *coronary artery of the stomach*, which extends along the smaller curvature of the stomach from its cardiac orifice.

B. The second of these is the *hepatic artery*, which passes upwards to the transverse fissure of the liver, where it divides and ramifies in the substance of the liver in the portal canals, along with the portal vein and hepatic duct.

C. The third branch of the cœliac axis is the *splenic artery*, which extends to the left above the pancreas to the spleen, giving off, however, some twigs to the cardiac surface of the stomach.

A fourth branch may go to the right supra-renal capsule.

The *superior mesenteric artery* is a very large vessel supplying the whole small intestine (except the duodenum), together with the cœcum and first part of the large intestine. It subdivides (to go to the intestine) in the folds of the peritoneum.

The *inferior mesenteric artery* is very much smaller than the artery last described. It passes out between the mesenteric peritoneal folds to the hinder part of the large intestine.

The *capsular* or *supra-renal arteries*, are very small. They arise, one on each side, near the superior mesenteric artery, and pass obliquely outwards, to organs hereafter to be described as the supra-renal capsules.

The *renal arteries* (Fig. 105, *a*) are exceedingly large, but short. They are two in number, and they pass out, one on each side, horizontally from the aorta, a little behind the superior mesenteric artery (that of the right being a little the more posterior, and, from the relation of the aorta to the spine, the longer), and go to the kidneys, each dividing into four or five branches before it penetrates the kidney, in the substance of which it ramifies, as will be hereafter described.

The *spermatic*, or *ovarian arteries*, are also two in number, but each is very long and exceedingly slender. They arise side by side, a little behind the renal arteries, from the ventral aspect of the

aorta. Each passes backwards and outwards, over the psoas muscle, to the internal abdominal ring, through which, in the male, it

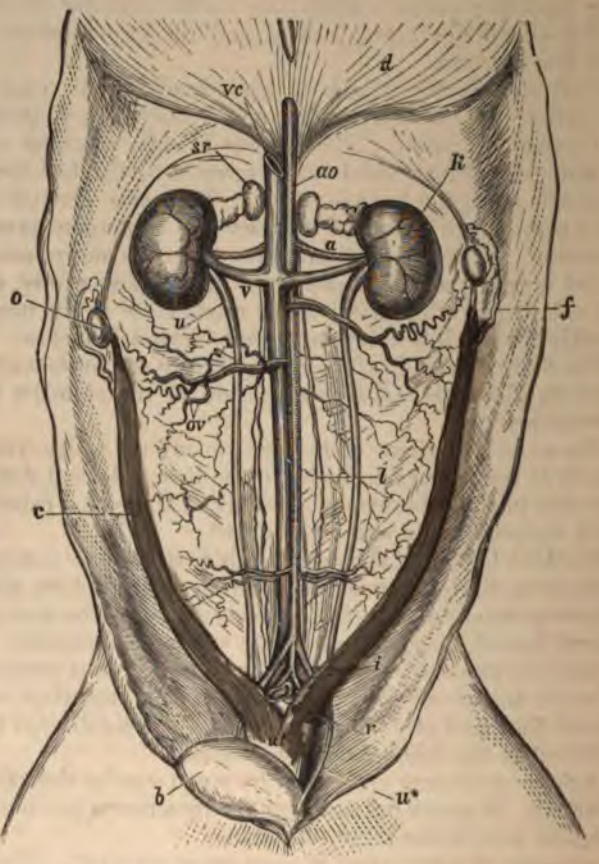


Fig 105.—Abdomen of a Female Cat opened, and with the Stomach, Intestines, Liver removed, so as to show the Kidneys, Uterus, Bladder, and G... Blood-vessels in position.

a. Renal artery.
ao. Aorta passing through the diaphragm.
b. Bladder.
c. Right cornu of uterus.
d. Part of the diaphragm with the opening for the vena cava.
f. Fallopian tube.
i. Left iliac arteries, showing the distinct origin from the aorta of both the external and internal iliac.
k. Kidney of left side.
l. Lymphatic vessel.
o. Ovary of right side.
ov. Ovarian vessels of right side.
r. Rectum, cut across behind the body of uterus.
sr. Supra-renal capsule of right side.
u. Ureter of right side, proceeding from kid...
u* Ureter of left side entering bladder.
ut. Uterus.
v. Renal vein.
vc. Vena cava inferior cut across above.

descends to the testicle. In the female, the vessel inclines inwar... and passes, between the folds of the broad ligament, to the ovary.

§ **20.** The ILIAC ARTERIES.—Having reached nearly the hinder e...

lominal cavity, the aorta gives off two large arteries which go
ich hind limb respectively, and each of which is named an
liac artery. After continuing on for a short space further,
gives off another pair of rather smaller vessels called the
liac arteries (Fig. 105, *i*) ; the aorta then immediately bends
ıpwards, and thenceforth continues onwards, gradually
g, beneath the middle of the tail as the *caudal artery*, which
twigs to the caudal muscles.

TERNAL ILIAC, or *hypogastric* artery, dips down into the
d gives off a variety of branches. Amongst them we have
or vesical, which goes to the side of the bladder, and is con-
th the umbilicus (or navel) by a fibrous cord—a relic of
tant fœtal structure ; the inferior *vesical*, which goes to the
ınd, in the male, to a part to be hereafter described as the
gland ; the *uterine* and *pudic* arteries, which go to the uterus
nal generative organs ; the *gluteal* artery, which passes out
lvis, between the pyriformis and gluteal muscles, supplying
; and the *sciatic* artery, which passes out of the pelvis at the
tic notch, and goes (between the greater trochanter and the
of the ischium) to the muscles of the hip and thigh.

The EXTERNAL ILIAC artery is very conspicuous on the
he thigh. It passes backwards, downwards, and outwards,
gives off a large branch called the *obturator* artery, which
of the pelvis through the obturator foramen. From the
artery is given off the *epigastric* artery, which passes for-
the middle of the abdominal wall, and anastomoses with
of the internal mammary artery.

passed beneath Poupart's ligament to the thigh, the ex-
c assumes the name of the *femoral artery*, and descends
inside of the thigh, resting successively on the psoas,
and adductor muscles. Near its origin, the femoral gives
branch called the *deep femoral*, which passes in through
tor muscle, and ramifies in the muscles of the hinder and
s of the thigh.

reaching the back of the knee-joint, the femoral artery
to the *anterior* and *posterior tibial arteries.*

STERIOR TIBIAL ARTERY runs down behind the tibia, upon
s posticus and flexor longus digitorum muscles, to the inner
e os calcis, where it divides into the *external* and *internal*
teries. The first of these goes to the base of the fifth
l, and then passes obliquely between the metatarsals to
e with the dorsal artery of the foot, so forming a plantar
ıe second, or internal plantar, proceeds along the inner side
of the foot towards the index.

sterior tibial gives origin to a branch called the *peroneal*
hich descends behind the leg close to the fibula, and in
with the flexor longus hallucis to the outside and back of
cis.

terior tibial artery passes forwards to the front of the

inter-osseous membrane. It then turns downwards and passes to the middle of the front of the ankle, where it assumes the name of *dorsal artery of the foot*, and runs on between the metatarsals of the index and middle digits, where it divides, one part sinking to anastomose with the external plantar artery (as already mentioned), and the other part going to the inner side of the foot. This and the plantar arteries give off small vessels to the digits, similar to those given off to the digits in the fore-paw.

§ 22. The VEINS are, with the exception of the portal vein, afferent vessels beginning by minute tubes, which converge and unite to form larger and larger trunks. They cannot, like the arteries, be grouped in only two sets of vessels—those of the pulmonary and of the systemic circulation respectively—because there are veins which belong to a third category, already noted as those of the portal circulation, which ramify and distribute the venous blood from the spleen, pancreas, stomach, and intestine, within the substance of the liver. With the exception, however, of the veins of the pulmonary and portal circulations, all the veins of the body are larger or smaller tributaries to those great vessels, already more than once referred to as the superior and inferior venæ cavæ, and which open directly into the right auricle of the heart. The veins which pass from the lungs to the left auricle, are those of the pulmonary circulation; while those veins which arise in the spleen, pancreas, stomach, and intestine, and those which ramify within the substance of the liver, together constitute the portal system. The whole of the blood passes at each circuit through both the pulmonary and systemic circulations, but only a portion of the blood has a share each time in the portal circulation. Thus both the systemic and pulmonary circulations are served both by arteries and by veins, and in each the blood is in one part arterial and in another venous, but the portal circulation is served by veins only, and its blood is venous entirely throughout.

There is yet another antithesis: in both the systemic and pulmonary circulations the circuit is complete, the vessels being connected together by capillaries, as well as by large trunks. The portal circulation is incomplete in so far as it is connected by minute vessels only, there being no direct connexion between the large trunks which send blood to, and those which receive it from, the liver.

The PULMONARY VEINS are the only veins which convey arterial blood. They arise by minute branches in the lungs (as will be again noticed with the description of the breathing organs); they converge to form four vessels, two on each side in the root of each lung. These empty themselves into the left auricle. Those of the right side pass behind the right pulmonary artery and on the dorsal side of the vena cava superior and the aorta. Those of the left side, which are the shorter, pass ventrally to the descending aorta.

The pulmonary veins of the right side unite with one trunk just before opening into the auricle.

As has been before said, many of the SYSTEMIC VEINS consist of a

double set, one deep and one subcutaneous. They moreover communicate and anastomose together more frequently than do the arteries. The systemic veins are naturally divisible into (1) those which ultimately pour themselves into the vena cava superior, and (2), those which convey blood to the vena cava inferior. To the first category belong the veins of the head, the pectoral limbs, the vertebral column, and part of the thoracic and abdominal walls. To the second category the veins of the pelvic limbs, of the lower part of the trunk, and of the abdominal viscera.

The veins of the outside of the cranium and face converge to form the *temporal, internal maxillary* and *facial veins;* the temporal passes through the parotid gland and becomes (having united with the two others), the EXTERNAL JUGULAR VEIN (see Fig. 88), which, beginning at the mandibular angle, descends, crossing the sterno-mastoid muscle, to the great *subclavian vein.*

The blood from the brain and inside of the cranium collects in reservoirs called the cranial sinuses, which groove the inner surfaces of the bones of the skull.* The blood from all these sources collects at the opening called the foramen lacerum posterius or jugular foramen, and the vein which passes out through it, receives the name of the INTERNAL JUGULAR VEIN, which vein descends outside and parallel with the common carotid artery, till it joins the *subclavian vein* (the junction being furnished with a valve), when the two, by their union, form the RIGHT INNOMINATE (or *brachio-cephalic*) vein.

The veins of the digits, fore-paw, and arm of each side, partly unite to form a sub-cutaneous network, which ends in larger channels (*radial, ulnar,* and *median*), which unite and end, sooner or later, in the *axillary vein.*

The veins of the digits, fore-paw, and arm, also unite to form a deep set of veins which accompany, as *venæ comites,* the tributaries of the *brachial vein,* uniting and ending ultimately in a single trunk, the AXILLARY VEIN, which, as it passes over the first rib, assumes the title of SUBCLAVIAN, and receives the contribution of the external jugular vein, as already mentioned, as also that of the *vertebral vein,* which descends through the canal of the cervical transverse processes in company with the ascending vertebral artery. Near the clavicle, the subclavian vein unites with the internal jugular to form the innominate vein already mentioned. Finally, the innominate vein unites with its fellow of the opposite side to form the VENA CAVA SUPERIOR, which passes down in front of the pulmonary vessels of the right side, and to the right of the aorta, to the right auricle.

Valves are found in the veins of the pectoral limb generally, but especially in the deep veins.

The veins of the digits, hind-paw, and leg of each side, also partly

* The middle of the skull roof and the occipital and temporal bones as already described, see *ante,* pp. 62 and 66.

unite to form a subcutaneous network, which ends in two main channels. The larger of these, the *saphenous vein*, runs up the inner side of the foot, leg, and thigh, beneath the skin, and terminates in the femoral vein.

The veins of the toes, hind-foot, and leg, also unite to form a deep set of veins, which accompany the arteries as *venæ comites*, and which are more richly supplied with valves than the superficial veins. The various tributaries ultimately unite to form the FEMORAL VEIN, which, as it passes beneath Poupart's ligament with the femoral artery, assumes the title of EXTERNAL ILIAC VEIN.

Meantime, the small veins of the pelvic viscera unite into larger vessels, generally corresponding with the divisions of the internal iliac artery (except that there is no remnant of any fœtal venous structure, save that going to the liver as the "round ligament"), and ultimately unite in a large valveless vessel called the INTERNAL ILIAC VEIN. The external and internal iliac veins unite to form a single vessel—the vena cava inferior.

This VENA CAVA INFERIOR is very much longer than the superior vena cava, and advances on the right side of the descending aorta. It then bends downwards, perforates the diaphragm, and ends in the right auricle. As it advances from its origin it receives important accessions, corresponding, to a certain extent, with branches directly given off from the abdominal aorta. They are :—

The *caudal vein*, which is really the posterior commencement of the lower vena cava, as the *caudal* artery is the real termination of the aorta.
The *lumbar veins*.
The *phrenic veins*.
The *spermatic veins*.
The *renal veins*.
The *capsular veins*.

All these sets of veins correspond with the similarly-named arteries, but there are no veins entering the vena cava which correspond with the superior and inferior mesenteric arteries, or with the cœliac axis, but veins enter it directly, which are called *hepatic*, though they do not correspond, either in situation or distribution, with the hepatic artery. They do not correspond in situation, because they enter the vena cava anteriorly to the point at which the cœliac axis (of which the hepatic artery is a branch) quits the aorta. They do not correspond in situation, because the hepatic artery enters the liver at its transverse fissure, and ramifies in the portal canals, while the hepatic veins run in quite differently directed channels, and converge to the groove in the dorsal margin of the liver, in which lies the vena cava, into which vessel they directly empty themselves. The hepatic veins are valveless.

§ **23.** The veins which correspond with the mesenteric arteries, and with the branches of the cœliac axis, constitute the PORTAL SYSTEM. Thus we have the *superior* and *inferior mesenteric veins*,

which converge as the corresponding arteries diverge, and empty themselves into the *splenic* vein, which returns blood from the pancreas as well as from the spleen, and also a vein from the stomach along its greater curvature.

The veins thus converging form the *portal vein*. This portal vein passes to the transverse fissure of the liver above the hepatic artery and duct, enclosed in the gastro-hepatic omentum. Arrived within the fissure, it divides right and left, and ramifies in the right and left portions of the liver, forming the great vessel of each portal canal. The portal vein is without valves.

§ **24.** Another system of venous structures goes by the name of the AZYGOS VEIN, although there are really a pair—one on each side. They are elongated vessels advancing one on each side of the spine, but more or less irregular in form and arrangement. They are formed by the union of the *intercostal veins* (corresponding with the intercostal arteries) and are tolerably symmetrical behind, but anteriorly some of the veins of the left side of the body, though not those of the three or four upper intercostal spaces, are poured into the right azygos vein, which thus becomes enlarged.

They begin behind in the lumbar veins, and the *right azygos vein* advances and passes through the diaphragm, with or near the aorta, till near the root of the right lung, where it turns downwards and empties itself into the vena cava superior (Fig. 104, *vz*), very near the right auricle.

The *left azygos vein* also commences with the lumbar veins, advances and passes through the diaphragm, with or near the aorta, and remaining very slender, ends by opening into the left innominate vein. The azygos veins have valves.

The veins of the heart itself open into the right auricle between the auriculo-ventricular opening and that of the vena cava inferior.

Thus the heart may be said to have a small circulation of its own—in addition to the systemic, pulmonary and portal circulations already mentioned. For blood from the coronary arteries* flows from the root of the aorta to the substance of the heart, whence it is directly returned by these coronary veins.

§ **25.** The *lymphatics* or *absorbent vessels* (including the alimentary *lacteals*,) seem to arise by minute vessels in every part of the body, which form a system of tubes (of different sizes,) and reservoirs (or sinuses).

Some of these latter are much dilated, for the great peritoneal sac, with the other serous sacs—including those investing the nervous centres—are to be regarded as being really large lymphatic sinuses or interspaces, because the lymphatic vessels communicate with the peritoneal cavity by definite apertures called *stomata*. Thus the lymphatic system is not so closed a system as is the

* See *ante*, p. 206.

sanguineous system. It is not so because the peritoneal cavity communicates (in the female cat) directly with the exterior by means of the Fallopian tubes, while the sanguineous system only communicates with it indirectly through the opening into it of certain lymphatic vessels. The mode in which lymphatic vessels absolutely commence is a matter not yet satisfactorily ascertained, but it seems they open at their minute extremities into mere vacuities in the ultimate parenchyma of the body. Thus the whole lymphatic system may be regarded as an enormously and most complexly ramifying body cavity, the ramifications of which have all acquired a lining membrane, save the most ultimate ones, from which ultimate terminations the lymphatic vessels, therefore, seem to take their origin.

The various lymphatic vessels ultimately gather themselves together from all parts of the body into one or other of two longitudinal vessels, which are named the *right* and *left lymphatic ducts*, and which are very unequal in size.

That of the right side receives only the lymphatics of the head and the fore-limb of its own side and from the same side of the chest. That of the left side receives not only the lymphatics of the head, arm and part of the chest of its own side, but also those of both the hinder limbs and all the lacteals. It is distinguished by a distinct name, the *thoracic duct*, but it and the right lymphatic duct, respectively open into the subclavian vein of its own side, just where it receives the accession of the jugular vein.

The THORACIC DUCT advances along the ventral side of the spinal column from a somewhat dilated part called the *receptaculum chyli*, which lies on the right side of and rather dorsally to the aorta. The duct passes forwards, inclining to the left, to the root of the neck, where it terminates, as before stated.

LYMPHATIC GLANDS.—There is a considerable *cervical gland*, about the size of a very small bean, just behind the external jugular vein at the level of the clavicle.

Other lymphatic glands lie near the axilla, a group of three or four being covered by the latissimus dorsi muscle near its insertion. Others are situated more deeply in the axilla itself.

A few lymphatic glands lie in the thigh just beneath the skin at about half an inch from the pubic symphysis.

Yet other lymphatic glands are to be found, besides various blood-vessels and viscera.

A large gland lies at about the middle of the trachea on its ventral aspect, immediately beneath the sterno-thyroid muscle, and a smaller one lies more anteriorly and superiorly near the angle of the mandible.

Certain lymphatic glands, placed in the mesentery, are known as *mesenteric glands*. The lacteals collect together and traverse them on their way to the larger lymphatic trunks. Most of the mesenteric glands are aggregated together into an elongated mass, which

is placed near the root of the mesentery, and which mass is often called the *pancreas of Aselli*. There are, however, five or six isolated glands of this kind in the vicinity of the large intestine.

After passing through the mesenteric glands, the lymphatics converge, increase in size, and finally enter the thoracic duct towards its hinder end.

CHAPTER VIII.

THE CAT'S ORGANS OF RESPIRATION AND SECRETION.

§ 1. The FUNCTION OF RESPIRATION is that one of all the functions of the body which is the most conspicuously necessary for the maintenance of life. Let this function be interrupted in the adult cat* but for ten minutes (whether by external obstruction, the absence of the requisite gaseous material, or by paralysis of the respiratory organs), and death is the necessary result. It has been already mentioned in the chapter on Alimentation, that oxygen is taken into the body through the lungs; and it has also been stated—in the last chapter—that the blood undergoes a conspicuous change (from its purple venous state to its scarlet arterial condition) during the pulmonary circulation. This change is due to the absorption by the blood, and consequent increase of its supply, of oxygen, and to the elimination from the blood of more or less of its carbonic acid.

It is this interchange of gases between the living animal and the surrounding air which constitutes "breathing," or *respiration*. But the animal we are considering may be said to have two processes of respiration—one "internal," the other relatively "external." Such is the case, because the oxygen received into the blood does not remain there, but is carried by the circulation to the remotest recesses of the body, where it unites with that body in its innermost substance or parenchyma.

Similarly, the carbonic acid which the blood sets free does not originate in the blood, but is given forth into the blood from all the ultimate particles of the same parenchyma.

Thence, the blood gathers it, and conveys it outwards for discharge in the lungs. The blood, therefore, is a great distributor, which both gives out and takes in oxygen and carbonic acid at either end of its course, from the lungs to the innermost body substance.

In the lungs it gives out carbonic acid, and takes in oxygen (as has just been said); while in the inmost recesses of the body it

* In the chapter on Development it will be explained how it is that interruption in the process of respiration is not so rapidly fatal in the kitten as it is in the adult cat.

gives out oxygen and takes in carbonic acid. *Internal respiratio* therefore, is the absorption of oxygen and the elimination of carbon acid by the ultimate parenchyma of the body's substance, which bathed by the nutritious oxygenated fluid as it exudes from th capillary vessels. *External respiration* is the absorption of oxyge and the elimination of carbonic acid by the blood, on what essentially the surface of the body; for the lining of the lungs is bu as it were, a very deep and complex inbending and infolding of th body's external surface, as has been already pointed out in th second chapter. The oxygen thus received in the lungs, appears part to form an actual chemical union with the matter of the re corpuscles, and in part to be dissolved in the liquor sanguinis. Th elimination of carbonic acid, it is maintained, is produced by a actual process of chemical decomposition.

It is necessary that the air respired be more or less fresh, and cannot be used over and over again an indefinite number of times for all that some oxygen still remains within it.

Ordinary atmospheric air contains nearly 7,900 parts of nitroge and 2,100 of oxygen, with a small quantity (3 parts in 10,000) carbonic acid.

The air expired, however, has about 470 parts of carbonic aci and less than 1,600 parts of oxygen—the quantity of nitroge remaining about the same as in fresh air. Thus about 5 per cen of oxygen is gained, and 5 per cent. of carbonic acid is lost in th process of respiration. These changes correspond with changes i the blood. Thus, in 100 parts of venous blood there may be fiv parts of oxygen and twenty-five of carbonic acid, while in the sam quantity of arterial blood there may be ten parts of oxygen an twenty of carbonic acid.

However rich in oxygen the air inspired may be, no more oxyge is absorbed than the processes of life demand. The organis regulates itself in this respect. The more the blood is charged wit carbonic acid, the greater is the quantity given off in the lungs.

If, instead of nitrogen, hydrogen or marsh gas be mixed wit oxygen in due proportion, and breathed, the compound can respired for an indefinite time. Some gases, however (such hydrochloric acid, sulphurous acid, ammonia, chlorine, fluorine, an others), cannot be respired, because their action is so irritating the breathing organs that the entrance to the windpipe becom involuntarily closed against them.

Other gases can be respired, but are poisonous if they a respired. Such are sulphuretted hydrogen, phosphuretted hydroge nitric oxide, carbonic oxide, and some others.

If pure oxygen be respired, it removes the carbonic acid from th blood too rapidly, so that the blood thereby ceases to possess necessary element for effecting the respiratory changes. The resu of this is death by what is called *apnœa*. Death produced b absence of oxygen, is called *asphyxia*.

The gaseous interchanges which take place in the lungs, are n

effected immediately by the fresh air last taken in, but only by after it has become diffused (according to the laws of gaseous diffusion) through the stationary air previously respired. It is effected by this stationary air because, as we shall shortly see, only a small part of the air which the lungs contain, is introduced or expelled at each respiratory movement. This stationary air is then the direct agent in effecting the exchange, and it is on this account that the air last expelled in each act of expiration, is the part most loaded with carbonic acid. Thus both external and internal respiration are processes which go on continuously, and without any such intermissions as those which take place in that alternating action which popularly goes by the name of "breathing," but which is merely a process of introducing into the body that material by which respiration, or true "breathing," can be effected.

§ 2. The process of respiration in the cat is something more than this mere interchange of gases, since whatever be the dryness of the air inspired, the air given forth in its breathing is nearly saturated with moisture, so that much water is thus given out from the body daily. Moreover, however cold may be the air taken into the body in breathing, the animal's breath as it is given forth is always hot, having become heated by the internal heat of the body. This heat is due to a process of chemical change taking place, as lately mentioned, in the innermost parenchyma of the body. Now, wherever chemical combination takes place, heat is evolved, and therefore those intimate processes of life which are effected by internal respiration have been described as a sort of slow combustion. External respiration then is the indirect cause of the heat of the cat's body, as may be shown by the increase of heat produced in it, by increased rapidity of breathing. Nevertheless, that it is only an indirect cause, is proved by the fact that the body may not only continue warm for some time after death, but that, under special circumstances, its temperature may temporarily increase.

This process of heat generation can go on as long as food is supplied, and the temperature of the body can be maintained at an even heat of about 100° Fahr., in spite of a very low external temperature in the winter season. The animal thus being always "warm-blooded."

By these chemical changes in the recesses of the tissues, not only is nutrition effected, but also the waste products of the wear and tear of life are removed by the introduced oxygen decomposing those products and converting them into soluble crystalloids or into gases —changes which enable them either to pass out readily at the lungs or else through the skin or through organs hereafter to be described, namely the kidneys.

The function of respiration as generally understood, *i.e.*, external respiration, is effected by a certain set of organs, which form two categories. The first category includes the *accessory organs of respiration*, or parts which convey air into the body, and which again expel it when it has done its work. The organs of the second

category, or the *essential respiratory organs*, are those which place the blood in intimate relation with the inspired air. To the first category belong the windpipe, and the grosser structure of the lungs, with the muscles and other parts which aid in drawing air inwards and in again expelling it. To the second category belong the minute cells which form the ultimate and essential parts of the lungs—the "air-cells" or "alveoli."

In the cat there is but one real set of respiratory organs; a certain respiratory action can indeed be also effected by the skin, but its amount is so minute it may be practically disregarded. Water ordinarily contains atmospheric air mixed up with it, but the cat has no organs by which the air thus contained can be respired, either by the external skin or by the lungs: for if water be introduced into the latter its introduction causes death, as also does the continued immersion of the whole skin in water. Nevertheless, as we shall see, the actual respiratory surface—the inner surface of the lungs—is always moist, and bathed with a thin watery film.

§ 3. The tube by which air is introduced into the cat's body is the windpipe, or *trachea*, which is relatively very capacious, and opens anteriorly in the back of the floor of the mouth, while posteriorly it divides into two branches, each of which is called a *bronchus*, and penetrates into one of the two lungs. At its front end the trachea expands into a membranous and cartilaginous box-like structure called the *larynx*, and it is the larynx which opens into the mouth behind the root of the tongue. The trachea passes downwards and backwards down the neck and along the thorax on the ventral side of the œsophagus. It remains permanently hollow, like an artery, its cavity being kept open by means of a series of incomplete cartilaginous rings which surround the windpipe in front and at the sides, but do not extend into its dorsal wall (adjoining the œsophagus), which is soft. The ventral surface of its hinder half is in contact with this thymus gland.

Its lower end lies above the sternum and the arch of the aorta. Above the pulmonary artery, the trachea divides into the two bronchi. The *right bronchus* is short, and passes horizontally into the root of the right lung. The left *bronchus* is somewhat the longer, and passes to the left lung behind the arch of the aorta. Within the lung the bronchi divide and subdivide, like the branches, branchlets, and twigs of a tree.

The cartilages of the trachea are forty-five in number, and are held in juxtaposition by fibrous membrane which embeds them. The highest cartilage is connected with and underlies the larynx. The soft layer which completes the trachea above, where the cartilaginous rings are incomplete, contains organic muscular fibres, internal to which is a stratum of elastic fibres which extend thence all round within the cartilages. More internally the tube is lined with mucous membrane, covered on its surface by a columnar and ciliated epithelium.

The *bronchi* have the same structure as the trachea, except that

their cartilaginous rings are shorter and narrower. The smaller tubes, into which the bronchi subdivide within the lungs, are called *bronchia*.

§ 4. The LUNGS (Fig. 89 and 112) are two in number, and are placed one on each side of the heart in the thorax. Together with the heart they fill up the main part of the whole thoracic cavity. They are attached each by a small part of its inner surface (called its root) to one of the two bronchi and to the great vessels connecting that lung with the heart—the blood-vessels and air-tubes entering or leaving the lung, passing through one or other of its "roots." From this attachment each lung hangs freely suspended, being conical in shape, with a broad, concave base, which is applied to the front surface of the diaphragm. Each lung is enclosed in a serous, shut sac, called a *pleura*, and the two pleuræ together may be said to form the proper serous sac of the thorax, though each is quite distinct from the other.

The two pleuræ line the right and left halves of the thorax, and are reflected over the two lungs at their roots respectively. In this way the two adjacent (inner) sides of the two pleuræ traverse the thorax from above downwards. They are not, however, in contact but separated by two interspaces termed *mediastina*.

The *anterior* mediastinum contains the heart in its pericardium.

The *posterior* mediastinum contains the œsophagus, the aorta, the vena azygos, and the thoracic duct, together with the two nerves called pneumogastric.

Each lung is divided by fissures into lobes as follows:

The left lung is divided by a deep fissure in two large and distinct lobes sub-equal in size (Fig. 104, [5] and [6]). A less deep fissure also separates off a small lower portion ([5]*a*) of the upper of the two lobes of the left lung. The right lung is divided by three deep fissures into four unequal and distinct lobes, the uppermost of these (Fig. 104, [1]) is large and triangular. The next ([2]) is narrow and elongated, but much smaller. The third lobe ([3]) is the largest of all, and has on its inner side the fourth lobe, which is incompletely divided by a fissure into a larger external part ([4]) and a much smaller internal portion ([4]*a*), both of which are narrow and pointed at the end.

As to their *minute structure*, the lungs consist of a prodigious number of small air-bags, called "lobules," attached to the finer ramifications of the bronchi. These lobules are united together by connective tissue with blood-vessels and muscular and elastic fibres, and can very plainly be discerned at the surface of the lung. The lungs may therefore be described as spongy and highly elastic organs which (when once respiration has taken place) will float if thrown into water, and which, if artifically inflated after removal from the body, will spontaneously contract and expel the air so introduced, through the elastic nature of their substance.

The smallest bronchial ramifications cease to be lined with ciliated epithelium, and have squamous epithelium instead.

Each bronchial tube, while still cylindrical, enters one of the lobules and there ramifies, its ramifications ultimately dilating into a larger passage called an infundibulum, the walls of which are beset with numerous little sac-like dilatations, called *air-cells, alveoli,* or *pulmonary vesicles.* These are naturally filled with air, and their membranous walls are strengthened with elastic and some muscular fibres, and beset with a multitude of delicate capillary vessels, which expose the blood they contain to the action of the air in the alveoli. The arteries (carrying the venous blood for oxygenation) end in minute twigs, which surround the margins of the alveoli, whence the capillary vessels extend inwards, and are subjected to the air on both sides of the moist, delicate membrane in which they ramify. The minute veins which issue from the capillaries, and which carry arterial blood, do not run side by side with the arteries, but, pursuing a different course, frequently anastomose and increase in size till they end in the great pulmonary veins, which proceed through the roots of the lungs to the left auricle, as before described.

Besides the pulmonary arteries (which bring blood for respiration), the lungs have their own proper arteries and veins, which are concerned in their nutrition. These are the *bronchial arteries and veins,* and they are smaller than the other blood-vessels of the lungs—the pulmonary arteries and veins.

The bronchial arteries are derived from the aorta, and follow the divisions of the bronchi within the lung. The bronchial veins unite together to pass out at the roots of the lungs.

§ 5. The MECHANISM OF RESPIRATION has already been slightly noticed, in the fifth chapter, in relation to the action of the diaphragm and intercostal muscles, which serve, by their alternate contraction and dilatation, to modify the capacity of the thorax. The serrati postici muscles, by drawing backwards the ribs to which the diaphragm is attached (at the very time that the other ribs are being drawn forwards, and the diaphragm, by its contraction, rendered less convex) aid in temporarily enlarging the thoracic cavity, and so causing an influx of air into the lungs. In this action the *serrati antici* and *scaleni* also give aid by drawing the anterior ribs forwards.

The pumping action of the diaphragm is the main agent in respiration, the relaxation of its fibres allowing it to become convex anteriorly, and so encroach upon the thoracic cavity—air being necessarily driven out of the lungs thereby. But the expulsion of air in expiration is largely due to the highly-elastic nature of the pulmonary structures (which has been already pointed out),* and to the muscular contraction of the bronchi. The abdominal muscles however are also called into play to effect a forcible expiration.

* It is owing to this elasticity that if a perforation be made in the wall of the thorax, the lungs will contract greatly. For by such injury the atmospheric pressure within, becomes neutralized by atmospheric pressure on their outer surface; from which pressure, the uninjured thoracic wall before protected them.

The alternation of acts of inspiration and expiration (one of the former commencing the series at birth, and one of the latter terminating it at death) goes on unceasingly, but at a rate which varies according to circumstances—being most frequent during violent exertion.

What is called the *respiratory rythm* consists of three parts: (1) the act of inspiration; (2) that of expiration, which endures but little more than half as long as the former; and (3) an interval of rest, which is much shorter than either.

Inspiration aids the circulation indirectly by pressing on the great vessels, the difference between the strength of the walls of the arteries and veins causing the pressure to be no impediment to the former, while the same pressure aids the flow of the blood in the latter.

APPLICATIONS OF THE RESPIRATORY ACTIONS produce a number of familiar actions, such as *yawning*, which is a prolonged inspiration; *coughing* and *sneezing*, which are sudden acts of expiration, the former being preceded by a prolonged inspiration—the air passing out by the mouth. In the latter it passes out only through the nose. All forms of mewing, howling, and other vocal manifestations, are modified expiratory actions.

The term VITAL CAPACITY refers to the capacity of the lungs as estimated by the greatest quantity of air which can be expelled from the lungs by the most forcible expiration after they have been inflated by the deepest inspiration. But no expiration, however violent or prolonged, will nearly expel the air which the lungs can be made to contain—while in ordinary respiration but a very small part ebbs and flows.

This small quantity is called the *breathing* or *tidal* air. That which always remains and can never be expelled is called the *residual* air; that which ordinarily remains in the lungs after expiration, but which can be expelled, is called the *reserve* or *supplemental* air, and that which can be drawn in by a prolonged inspiration, beyond that ordinarily so taken, is termed the *complemental* air. These phenomena have been accurately observed only in man, but the essential conditions are the same in the cat.

§ **6**. It has just been said that all vocal manifestations are modified expiratory actions; but these actions, in order that they should produce sounds, need the aid of a peculiar mechanism. This mechanism is furnished by that expanded, anterior end of the windpipe which has been already referred to as the LARYNX.

To the upper, anterior margin of the larynx, the hyoid bone is attached, and therefore also the tongue, behind the root of which the laryngeal opening into the pharynx—the "glottis"—already spoken of as situated in front of the œsophageal opening, and as being protected by that cartilaginous process the epiglottis, which stands up in front of it. The larynx is formed of three large and two small cartilages, united together by fibrous tissue moved by muscles, and supplied with blood-vessels, lymphatics, and nerves, the whole structure

lined with mucous membrane, which is supplied with numerous us glands. Amongst the parts formed of fibrous tissue are nternal ligaments on each side of its cavity, called the *vocal* which are the immediate agents in the production of the

The whole of the inside of the larynx below these cords ited with ciliated epithelium, and also for a short distance them. The action of the cilia is to l the mucous secretion towards the aperture of the larynx.

THE CARTILAGES OF THE LARYNX.

are median, azygos structures, and thers are arranged as a pair.

e largest of the three median struc- is called the *thyroid* cartilage, which sts of two lateral parts (*alæ*) united acute angle or sharp curve, opening vards—*i.e.*, dorsally. Each ala is what quadrilateral (an elongated paral- am) with its anterior (ventral) border re it joins its fellow of the opposite the shortest, while its posterior border longed upwards and a little down- , into two rather blunt processes d *cornua*. The two posterior borders early vertical, with an undulating in, and are widely separated from nother. The inferior margin of each s concave in front of the inferior , while more anteriorly it is slightly x, and then concave, so that there is ht median notch at the under border e thyroid. The superior margin of ala is also concave in front of the ior cornu, while more anteriorly it is gly convex, there being no notch at oint where the upper margins of vo alæ meet together in front. Each smooth and rather concave within, above downwards. The superior a are connected by a ligament called hyro-hyoid ligament, with the tip of the thyro-hyal of the side. They are also closely connected, through the medium e thyro- and cerato-hyals, with the stylo-hyals. Each inferior articulates with the outside of the cartilage to be next de- d. It is much shorter than the superior cornu.

Fig. 106.—VIEW OF THE RIGHT SIDE OF THE CARTILAGES OF THE CAT'S LARYNX—SEEN MORE OR LESS SEPARATED.

The uppermost is the epiglottis (*e*).

th. Is the thyroid, and (*c*) is its superior cornu. The small cartilage below is one of the arytenoids, with an articular surface for the cricoid (*a*), and with a small process (*cl*) at its summit.

Beneath is the cricoid (*cr*, with the articular surface for the arytenoid indicated immediately beneath the representation of that small cartilage.

1, 2, 3, and 4, are the four uppermost rings of the trachea.

e *cricoid cartilage* is ring-shaped, and may be considered as the ied, topmost cartilage of the trachea. Greatly modified it nly is, since, instead of being defective behind, as are the eal cartilages, and as is the thyroid cartilage, it is much larger,

and more developed behind than elsewhere. Its lower border is slightly undulating, and is connected by membrane with the uppermost cartilage of the trachea. Its convex upper posterior border has a scarcely perceptible median notch, and on each side of this is an oval, convex, articular facet. Internally this cartilage is lined by the mucous membrane of the larynx.

The third median cartilage is the *epiglottis*, which is acutely pointed above and very obtusely so below, where it is attached by ligament to the inside of the thyroid. The posterior (dorsal) surface of the epiglottis is concave from side to side. Vertically, its anterior (ventral) aspect is concave above and convex below (Fig. 106). It is invested with mucous membrane both in front and behind, except

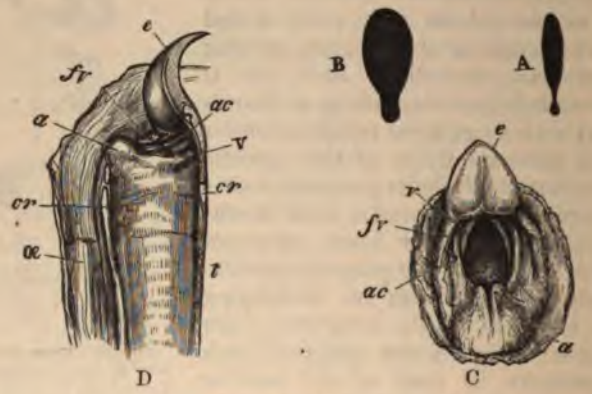


Fig. 107.—THE LARYNX AND GLOTTIS OF THE CAT.

A. Aperture of the glottis contracted.
B. The same dilated.
C. Opening into the larynx.
a. Arytenoid cartilages.
ac. False vocal cords.
e. Epiglottis.
fv. Crico-epiglottic ligaments.
v. True vocal cords.
D. Vertical section through the trachea and œsophagus.
a, *ac*, *e*, and *fv*, as in figure C.
Between *ac* and *v* is the ventricle of the larynx.
cr. Cricoid cartilage cut through.
œ. Œsophagus.
t. Trachea.

the lower part of its front surface, where it is attached to the tongue and hyoid by ligaments—that which connects it with the hyoid being elastic. It is connected on each side by a strong fold with (Fig. 107, *fv*) the side of the cricoid cartilage close to the base of the arytenoid cartilages.

The two *arytenoid cartilages* rest each on one of the two oval articular surfaces before mentioned as situated one on each side of the median posterior notch, in the upper border of the cricoid cartilage. Each arytenoid cartilage is irregularly pyramidal in shape, the base of each pyramid resting on the cricoid. The summits of the arytenoid cartilages curve somewhat towards each other.

A good many *ligaments* connect the different portions of the larynx. Thus there is the *thyro-epiglottic* and *hyo-epiglottic* connecting the epiglottis with the thyroid and os hyoides respectively.

The *aryteno-epiglottic*, which might be called "crico-epiglottic," is a thick fold of membrane (Fig. 107, *je*) which proceeds from the base of the outside of each arytenoid and contiguous part of the cricoid, to the side of the epiglottis. The *thyro-hyoid* connects the os hyoides with the thyroid, while the *crico-thyroid* connects the latter with the cricoid, filling up the interval between them and containing much elastic tissue.

The most important ligaments, however, are those called the "vocal cords," of which there are two kinds on either side of the cavity of the larynx. The *superior* or *false vocal cords*—called also the *superior thyro-arytenoid ligaments*—are folds of membrane which pass (one on each side) from the anterior aspect of the arytenoid cartilages downwards and forwards to the mucous membrane of the middle of the posterior (dorsal) surface of the epiglottis and thyroid (Fig. 107, *ac*). These are very prominent folds of membrane, and it is by their vibrations that the sound of "purring" is said to be produced.

The *inferior* or *true vocal cords*—called also the *inferior thyro-arytenoid ligaments*—have a similar but lower origin and insertion to the false vocal cords (Fig. 107, *v*); they are less prominent and sharply edged. It is these true vocal cords which by their vibrations are said to produce the mewing and howling sounds. These cords leave between them an aperture termed the *rima glottidis*, and they tend to form a horizontal partition dividing the cavity of the larynx into an upper (anterior) and a lower (posterior) portion. The whole larynx opens into the pharynx by its superior aperture—the *glottis*—which is bounded in front by the epiglottis, behind by the arytenoid cartilages, and on each side by the aryteno-epiglottidean folds, and by the false vocal cords. Between the false and true vocal cords of each side is a small depression called a "*ventricle*." These two depressions, however, are so slight as hardly to deserve notice.

§ 7. The VOICE is produced by the vibration of the edges of the vocal cords (when stretched and approximated), which vibration is effected through the passage outwards of a stream of air, according to the laws which regulate the vibrations of strings and membranes. Accordingly, certain muscles act upon the arytenoid cartilages, and by their action put the membranes on the stretch, and so alter the shape of the opening of the glottis by contracting it (Fig. 107, A & B). The more the cords are stretched, and the narrower the aperture, the shriller are the sounds emitted.

Though the vocal cords are the main agents in the production of sounds, the tone and qualities of these sounds are modified by shape of the cavities of the larynx, pharynx, and even of the air-cavities of the skull, and by the physical qualities of all these parts. To effect the needful changes, appropriate motor agents are needed, and there are no less than eight pairs of laryngeal muscles. The *crico-thyroid* muscles extend from the upper border of the cricoid to the outside of the thyroid and its lower cornua. Their action is to rotate the thyroid downwards and to stretch the vocal cords. Two pairs of

muscles—*posterior and lateral crico-arytenoids*—pass from the crico to different parts of the arytenoids, which the former rotate ou wards, and the latter inwards, thus either widening or contracti the glottis. The *thyro-arytenoids* and the *arteno-epiglottidean* muscl have the same connexions as the true vocal cords and the aryten epiglottic ligaments respectively. The *glosso-epiglottidean* muscl pass from the back of the tongue downwards to the base of t front of the epiglottis, and the *hyo-epiglottidean* muscles are ve small ones, extending from the hinder surface of the basi-hyal, do to nearly the same part of the epiglottis as that into which the la mentioned muscles are inserted.

Lastly, the *arytenoid* muscles connect and tend to approximate t two arytenoid cartilages.

§ **8**. In treating of respiration and the respiratory organs, we ha mainly been occupied with that which ministers to the nutrition a warmth of the body by enabling it to obtain its due supply of oxyg We have, however, also noted that the process of respiration is in p a process of elimination and removal from the body of a portion of t waste products of its vital activities. This now requires more care consideration. Life is a series of compositions and decompositio and in order that assimilation may go on, a process of disassimilati must necessarily accompany it. With the addition of new and unu material, there must go on a subtraction of old and effete material, a this (as we have lately seen) is mainly brought about by a process oxydation in the inmost parenchyma of the body. We have se in studying alimentation, that colloids have to be changed i crystalloids, that they may be conveyed to the colloidal parenchyn into which they have to be transformed. Similarly in the process disassimilation, the effete colloidal parenchyma has to be reconver into crystalloids that it may be conveyed away and excreted, thou the crystalloids of excretion are generally different from those nutrition.

It has also already been pointed out that the digestion of t food is aided by the juices of the salivary glands and pancreas, a other similar structures. Now these juices do not exist as such the blood, but are formed from it by a mysterious power wh certain cells possess thus to form new products. The exerc of this power is called "*secretion*," and it is a power analog to that by which the various tissues are enabled to add to th own substance from the life-stream which bathes them, thou their substance does not exist, as such, in that stream. Th "assimilation" is a sort of "secretion." Nevertheless it cannot said that "secretion" is a sort of "assimilation." "Assimilation" a process of forming products and adding them to the body; b "secretion" is a process of forming products which are to be got of, or are destined to aid in other life processes. Thus secretion i special function, and as such has a special organ—a gland. Glan as we have already seen, are either simple or complex involuti of an epithelial surface. We have seen simple ones in the swe

and mucous glands, and complex ones in the salivary glands, the pancreas, and above all, the liver. The foldings or subdivisions of a gland are manifestly but a convenient mode of augmenting the secreting surface within a small space. Since all secretions are

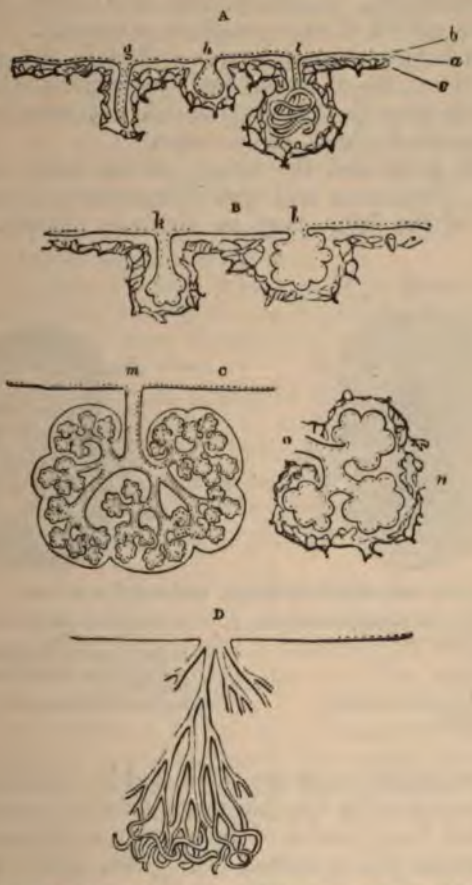


FIG. 108.—DIAGRAM OF DIFFERENT FORMS OF GLANDS, SHOWING HOW THE SECRETING SURFACE MAY BE AUGMENTED, AND THE GLANDULAR STRUCTURE RENDERED MORE COMPLEX BY INVERSION OR RECESSION OF THE SURFACE TO A GREATER AND GREATER DEGREE.

A. Simple glands.
- *g.* Straight tube.
- *h.* Sac.
- *i.* Coiled tube.

B. Slightly more complex forms.
- *k.* Tubular.
- *l.* Saccular.

C. Racemose or compound saccular gland
- *m.* The entire gland, showing its branching duct and lobular structure.
- *n.* A separated lobule, with one branch of the duct (*o*) proceeding from it.

D. Compound tubular gland.

Secreting surfaces may also be increased by projections and foldings outwards, analogous to these inversions and foldings inwards.

formed from the blood, every secreting surface, and therefore every gland, must be highly vascular. It is as yet quite unknown what causes different epithelial cells to have the power of forming such

different secretions as are those, for example, of the sweat glands, salivary glands, synovial membrane, and liver. The undivided tube of a gland by which its secretion is poured out is its *duct*. The secretions, and therefore their glands may, as we have seen, simply serve to aid the process of assimilation. They may also aid the function of generation, or, finally, they may merely serve for excretion, *i. e.*, to get rid of waste products or excreta. Certain large and small glands have already been described in the sixth chapter, namely, the liver, the pancreas and the various salivary glands. The anal glands were also therein noticed. It remains to describe those very important glands, the kidneys.

§ **9.** As the foods and the tissues of the body may both be divided into nitrogenous and non-nitrogenous substances, so also the excreta of the body may be similarly divided. The *non-*

Fig. 109. – THE CAT'S KIDNEY, ENTIRE AND IN SECTION.

A. The outer surface of the kidney, showing the network of blood-vessels.
a. Renal artery.
u. Ureter.
v. Renal vein.
B. Vertical section through the kidney.
c. Cortical substance.
i. Expanded end of the calix surrounding the mammilla.
o. Dark spots in cortical substance.
p. Papilla, or mammilla.
pl. Pelvis.
t. Tubules of the kidney.

nitrogenous products of waste are eliminated by the lungs, and to a very much less degree by the skin in the form of water and carbonic acid. But a very large portion of the waste products are nitrogenous. These are eliminated in a trifling degree also by the skin, but the special organs for their elimination are the *renal organs* or *kidneys*. A process of oxidation in the innermost substance of the body converts the nitrogenous waste matter into *urea*, uric acid, ammonia, and certain other acids and salts which are crystalloidal derivations from colloidal tissues. The kidneys extract all these, with much water, from the blood, and so form urine.

§ **10.** The KIDNEYS differ from the lungs in that they are organs of excretion only. The lungs excrete, but as we have just seen, they also take in. The secretion of the kidney, the urine, passes down from those organs by two tubes into a receptacle—the bladder—where it accumulates, and whence it is expelled at intervals.

The kidneys are two organs placed one on either side of the

vertebral column, a little behind the attachment of the diaphragm (Fig. 105) They lie against the dorsal wall of the abdominal cavity above (*i.e.*, the dorsal side of) its peritoneal lining. The anterior end of the right kidney adjoins the posterior surface of the liver. The left kidney is in proximity to the spleen.

Each kidney is a rounded body, smooth externally, and showing superficially an arborescent network of veins (Fig. 109, A.) It is convex everywhere, except on its inner side, where it presents a marked concavity. From the middle of this concavity a tube, called the *ureter*, proceeds inwards and backwards to the bladder (Fig. 105, *u*). This tube is the duct of the renal gland, and it emerges from a fissure in the concave surface, called the *hilus* of the kidney. From this hilus the renal vein (Fig. 109, A, *v*) also issues, and into it the renal artery (*a*) and the nerves enter. The artery enters on the dorsal side of the emergence of the vein.

As to its *structure*, the kidney consists of an immense multitude of minute tubes, with vessels, nerves, connective tissue and fat, all enclosed in a thin but firm fibrous coat, which closely invests the gland and contains elastic fibres.

On making a longitudinal section of the kidney it is seen to be of a more or less red colour and to contain a heart-shaped cavity (Fig. 109, B, *pl*) towards its inner border. Its solid substance appears divisible into an external layer of a lighter tint, containing minute dark red spots (*o*)—the *cortical* substance—while the rest is darker coloured and forms what is termed the *medullary* substance.

The cavity above referred to is the continuation inwards of that of the duct of the gland (the ureter), and is called the *pelvis* (*pl*). As the pelvis penetrates the gland it enlarges (*i*) and surrounds a central prominence which projects into it. The part surrounding this prominence is called the *calix*.

The cortical substance forms one continuous layer, and the medullary substance is also arranged in a conical mass or pyramid, the apex of which is directed inwards and projects into the calix as the *mammilla* or *papilla* (*p*), the tubes of which it is composed (*t*) converging to the mammilla.

The pelvis is lined with mucous membrane, which is reflected over the apex of the mammilla.

The minute tubes (*t*) of which the kidney is mainly composed are called TUBULI URINIFERI. They are very closely packed, and consist of a transparent membrane lined with a polygonal or a spheroidal and glandular epithelium occupying two-thirds of their diameter. These tubuli open on the surface of the mammilla, whence they pass into the substance of the kidney, dividing and subdividing, but continuing a nearly straight course till they come to the cortical layer, where they become much smaller in size and variously contorted in all directions, whilst they freely anastomose. Scattered about in the cortical substance are small capsules (the red specks already spoken of) or *Malpighian corpuscles*. These are

the expanded terminations of the contorted uriniferous tubes. Each such corpuscle contains a bunch of minute looped capillary vessels forming what is called a *glomerulus* (Fig. 110, *h*), and has itself a most delicate epithelial lining contrasting with the thick spheroidal lining of the uriniferous tubes. A small artery enters each glomerulus, and there breaks up into a number of minute branches ending in a capillary network, whence a small vein (Fig. 111, *e'*) arises,

Fig. 110.—SEMI-DIAGRAMMATIC REPRESENTATION OF A MALPIGHIAN BODY IN ITS RELATION TO THE URINIFEROUS TUBE. MAGNIFIED 300 DIAMETERS.

a. Capsule of the Malpighian body continuous with (*b*), the membrana propria of the coiled uriniferous tube.
c. Epithelium of the Malpighian body.
d. Epithelium of the uriniferous tube.
e. Detached epithelium.
f. Afferent vessel.
g. Efferent vessel.
h. Convoluted vessels of the glomerulus.

Fig. 111.—DIAGRAM SHOWING THE RELATION OF THE MALPIGHIAN BODY TO THE URINIFEROUS DUCTS AND BLOOD-VESSELS.

a. One of the arteries.
a'. A branch passing to the glomerulus.
c. Capsule of the Malpighian body.
t. Uriniferous tubes.
e', *e'*. Efferent vessels, which subdivide in the plexus (*p*), surrounding the tube, and finally terminate in the branch of the renal vein (*c*).

which leaves the glomerulus, and breaks up into another network or plexus (Fig. 111, *p*) of capillaries surrounding the tubules, whence arise other veins, which convey the blood ultimately to the renal vein. Thus we have in the kidney a multitude of minute special circulations, each of which is analogous to the portal system or that of the coronary vessels of the heart.

The FUNCTION of the kidney is, as has been said, to remove nitrogenous waste products and salts from the blood by the secretion and excretion of urine, and it thus supplements the action of the lungs by the removal of matters which escape the action of the pulmonary organs. The blood comes, as we have seen, to the kidneys direct from the abdominal aorta, and is therefore as pure as when it leaves the left ventricle. In circulating through the kidney it is still further purified, namely, from its nitrogenous waste matters, and it also loses more carbonic acid by the formation of urine, than it acquires by any wear and tear of the tissues of the gland. Thus the blood which leaves the kidney is at its maximum

of purity and oxygenation, and is as bright and scarlet as when it entered it.

The watery substance of the urine appears to drain from the vessels of the glomerulus into the cavities of the Malpighian corpuscles, and its more solid constituents to be secreted by the thick epithelium of the tubules.

Some of the constituents of the urine—such as urea, uric acid, and a substance called kreatine—already exist in the blood which comes to the kidneys, and their elimination therefore is rather an excretion than a true secretion; not but what it may be doubted whether any such a purely passive and physical process as a mere straining-off action, really takes place in the living organism at all.*

The action of the kidney is constant, and small quantities of urine are continually passing from the mammilla of each kidney to the pelvis, and thence, down the ureters, into the bladder.

§ 11. The URETERS are, as has been already explained, *two ducts or tubes which proceed one from the pelvis of each kidney. They lie* on the dorsal side of the peritoneum, and *proceed inwards and* backwards to the bladder (*Fig.* 105), *being connected by loose* areolar tissue to the parts adjacent to them.

They enter the wall of the bladder very obliquely, opening within it each by a narrow, slit-like aperture, the margins of which are somewhat thickened so as to have a valvular action and check the regress of urine from the bladder into the ureters.

Each tube consists of a canal of mucous membrane, lined with epithelium; the mucous tube being invested with organic muscular fibres, which are again invested externally by connective and elastic tissue.

§ 12. The BLADDER (Figs. 105 *b* and 115), is a hollow, rounded vessel with three openings, two (those of the ureters,) by which the urine is received, and one (that of the urethra,) by which it is discharged. These three apertures define a triangular portion of the bladder called the *trigone*.

The bladder is connected with the anterior wall of the abdomen, the umbilicus, by a fibrous cord called the *urachus*, which is the remnant of a fœtal structure, and at least occasionally includes a small irregular internal cavity lined with epithelium.

The bladder is also attached to adjacent parts by folds of peritoneum and of fascia. The inside of the bladder is lined with mucous membrane invested with squamous epithelium. The mucous

* The pungent, and to most persons disagreeable, odour of the male cat is dimorphous. Certainly here due to causes other than those which determine the sexual function of renal secretion, since it is absent from the urine of the female cat, and also from that of the castrated male. The urine of all the species of the cat family has (as far as known) a more or less powerful and disagreeable smell, but its odorous qualities differ much in different species, as the author has been assured by Mr. A. D. Bartlett.

lining is loosely attached to the outer coats of the bladder and is therefore thrown into folds when the viscus is empty.

The outer coats of the bladder are muscular and fibrous. It is muscular coat is formed of organic fibres in several layers. It is

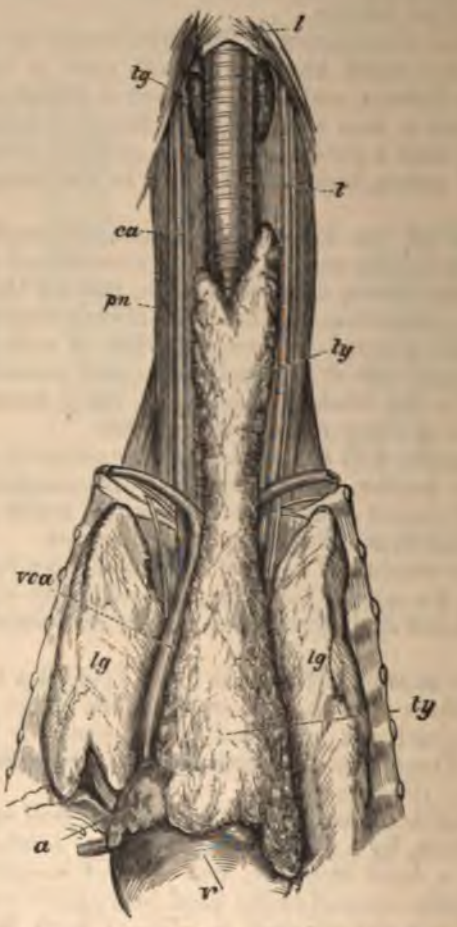


Fig. 112.—Portion of the Neck and Thorax of a Kitten, dissected to display the large Thymus Gland.

a. Right auricle of heart.
ca. Carotid artery.
l. Larynx.
lg. Lung.
pn. Pneumogastric nerve.
t. Trachea.
tg. Thyroid gland.
ty. Thymus gland.
v. Ventricle.
vca. Vena cava anterior.

fibres are all so arranged as to remind us of figures of **8**. They extend in almost every direction, and intersect each other on the front and hind surfaces of the bladder. Towards the orifice leading

the urethra the fibres assume a circular course, and so form a somewhat dense mass called the sphincter of the bladder.

External to the muscular coat is the fibrous investment of the bladder.

The passage by which the urine passes from the bladder to the exterior is named the *urethra*.

The urine is expelled by contraction of the muscular coat and relaxation of the sphincter, and is aided by contraction of the abdominal muscles and diaphragm and by a small muscle called the *accelerator urinæ* (Fig. 115, ^{2}).

§ 13. The SUPRARENAL CAPSULES are two small roundish, somewhat flattened bodies (Fig. 105, *sr*), situated one in the vicinity of the inner part of the anterior end of each kidney, being attached there by areolar tissue. Each consists of an outer *cortical* part, of a firm consistency and yellow colour, and an inner softer and darker medullary portion. It has a fibrous investing membrane intimately connected with the cortical substance, which is made up of delicate filamentous tissue with interspaces filled with granular matter, nucleated cells and oil globules. These organs are richly supplied with nerves, but they have no duct, and their function is quite unknown.

§ 14. The THYROID BODY *or gland* is another ductless structure of unknown function. It is very vascular, of a soft consistency and reddish colour, and lies (Fig. 112, *tg*) beside the trachea just below the larynx. It consists of two lateral parts, each of about the size of a small bean. There is no median connecting portion, so that there should rather be said to be two thyroid glands than one. It is composed of a number of minute, closed vesicles, which contain a yellowish, glairy fluid, and are connected by areolar tissue; a thin but dense layer of which is the external investment. The thyroid body is supposed by some physiologists to regulate the supply of blood to the brain, and to prevent undue cerebral pressure by acting as a collateral blood reservoir.

§ 15. The THYMUS is a structure which is of very large size during immaturity, but becomes smaller in the adult cat. Like the thyroid it is a ductless structure of unknown function. It lies on the dorsal side of the sternum on the ventral aspect of the great vessels, and extends also far up the neck on the ventral surface of the trachea, as represented in Fig. 112. It is of a greyish or pinkish colour, and is soft and pulpy in consisteney. It contains a central cavity, around which are arranged a number of lobes and lobules made up of delicate cells. A milky fluid is found within it, containing many nuclei and small nucleated cells.

§ 16. Other DUCTLESS GLANDS are the closed follicles which make up the "Peyer's patches," and "solitary glands" of similar nature have been already mentioned as being found in the intestine. Another very small structure of a similar nature is called the "pituitary body." It will be hereafter noticed in describing the brain, to the under surface of which it is attached, lying within the sella turcica or the dorsum of the basi-sphenoid bone (Fig. 128). Yet

other ductless glands are the various lymphatic glands alrea spoken of in the last chapter.

§ **17.** Another viscus, and one of large size, is akin in nature the lymphatic glands. This is a large ductless organ already m tioned as lying in the abdomen in the vicinity of the pancreas, cl to the left side of the stomach. It is called the SPLEEN. It is so what variable as to shape and size, generally in the form of elongated triangle, somewhat bent on itself, of a dark bluish colo lying immediately behind the diaphragm. It is convex and smo on its left side and concave on the side which is applied to stomach, which is marked by a vertical fissure, called the *hi* where the vessels and nerves pass into and out from its substance

Besides the peritoneum, the spleen is invested with a fibrous very elastic coat which, at the hilus, is reflected into the body the viscus, forming sheaths and canals for the large blood-ves

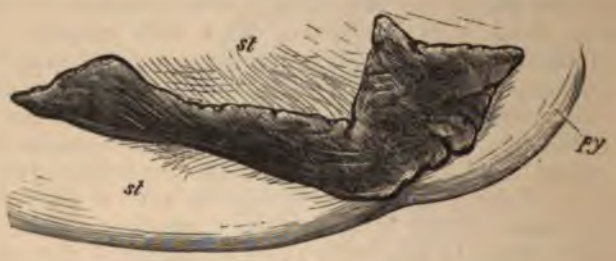


Fig. 113.—THE SPLEEN.

st. Wall of stomach *py.* Pyloric portion of stomach

and nerves which ramify within it. Thus is formed a highly tensible framework composed of areolar tissue, with a large quan of elastic fibres. Amongst these elastic structures, with t vessels, is the red pulpy substance of the spleen. This is formed nucleated and non-nucleated granular bodies, amongst which scattered numerous whitish vesicles, called *Malpighian corpuscles* of spleen, attached like buds to the sides of the minute branches of arteries, and each composed of a fibrous bag enclosing granu nucleated corpuscles.

The FUNCTION of the spleen is so far related to alimentation t the organ begins to dilate while digestion progresses, reaching largest dimension after a meal; while later, if no fresh food taken, it becomes reduced to its smallest size. A very remarka fact, however, about the spleen is that it can be entirely extirpa without its loss producing any strikingly injurious effect. function usually attributed to it is that of helping to replenish nutritious fluid by forming lymph cells, which pass from it dire into the blood. Much obscurity, however, still remains as to entire part it plays in the activities of life, and as to what may really its main function.

§ 18. We have hitherto considered various organs which could be classed as alimentary or secreting organs, and some (like the pancreas, &c.) which were both alimentary and secreting structures, since they secreted a fluid destined to assist in alimentation. Such secretions, however, were always destined for the service of the secreting organism itself, and to help its own alimentary processes. But we have now to consider organs which are indeed both secreting and alimentary, but which secrete an aliment for the use of another organism than that which forms it. These are the MAMMARY GLANDS, or breasts, which secrete the milk destined to nourish the young. Hitherto we have met with a variety of organs, but only with organs which are pretty equally developed in every individual cat. The mammary glands, however, are parts which attain a large size and perform an important function, only in one set of individuals of the species we are occupied with—namely, in female individuals. These glands form a considerable mass, extending on each side of the ventral surface of the body, from near the axilla to the hinder end of the abdomen. Each gland is invested by fibrous tissue, which sends in septa (between the various parts of the secreting glands), accompanied by much adipose tissue. The ultimate structure of each gland consists of minute secreting cells bound up by connective tissue into little "glandules," each giving out a small duct, which originates from the cellules and then joins with others to give rise to larger milk tubes, which ultimately end in certain conical dilatations or "*reservoirs*," from which very small excretory ducts extend forwards to a prominence or *nipple*, where they open by minute apertures.

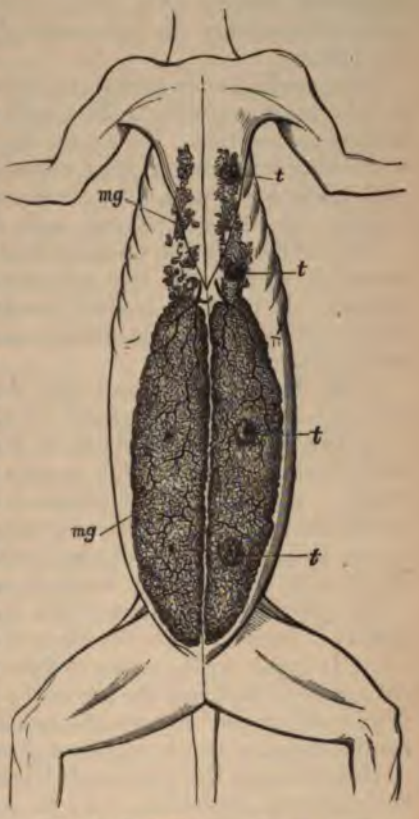


Fig. 114.—CAT'S MAMMARY GLANDS, WHEN FUNCTIONALLY ACTIVE.

mg. Mammary glands. Teats.

The excretory ducts are formed of connective and elastic tissue, with an epithelial lining of small columnar cells.

Each nipple is highly vascular, and contains organic muscular fibres, and its surface is beset with sensitive papillæ. There are

eight nipples—four on each side, one close to the anterior, and on near the hinder end of the glandular structure.

These glands become greatly enlarged when in use, especially th abdominal portion (Fig. 114). In the male the mammary gland quite rudimentary, though essentially similar in structure to that the female.

These milk glands may be regarded as greatly enlarged and aggre gated sebaceous glands, and the milk which they secrete, as a modifie sebaceous secretion. The MILK they form is an opaque white fluid containing much water, with certain salts of potassium and sodium with phosphoric acid, iron, milk-sugar, some albuminous matter (casein and a little albumen), with fats and some other substances.

The milk being the destined food of the kitten, contains all th materials needed for the nourishment and growth of the young animal. It contains in fact a suitable and nicely balanced suppl of nitrogenous and non-nitrogenous, albuminoid, fatty, amylaceou and saccharine matters.

§ **19.** In the structures last described we have found organ destined for the nourishment of another individual; but we hav next to consider organs destined for the actual *formation* of othe individuals. Such are the organs of REPRODUCTION, or *generati organs*: the business of which is to manufacture, and to render serviceable certain diverse products which concur in giving rise a new living organism, destined with growth to become an anim like that by which one or other of such products have been secrete

The products thus formed are essentially of two kinds, and th faculty of forming one or the other of them constitutes the difference *sex*. It is only by the union of these two kinds of products that a ne cat can be formed, and the process by which that formation takes pla after such a union has been effected, is the process of development, th consideration of which will occupy us in the next chapter but one.

But although the process of development will there be considere the nature of generation may be more fitly spoken of here. Th process of growth has been already many times referred to, an even in the second chapter facts as to the growth of epithelial cell of cartilage and bone, were brought before the reader's notice; an in the chapter on the organs of circulation, we saw how lymp corpuscles grow by spontaneous self-division within the substance the lymphatic glands. In all these processes of growth, we hav indeed, already become acquainted with a sort of reproduction, f it is by the reproduction of the component cells of the various tissu that their growth is effected. The fact then of an organ secretin cells which detach themselves in order to perform special function is a fact which has now no novelty for us. Indeed we have m with a truly complex form of reproduction, in the developme from the milk-tooth's sac of a bud or off-shoot, capable of growin into the permanent dental structure by which such milk-tooth ultimately replaced. Nevertheless, although generation may b said to be a kind of growth; yet it is a very special and peculi *kind of growth*. By it in the first place is formed a cell capable b

self-division and metamorphosis of growing up not into a single organ only, but into a perfect animal like that which produced it. In the second place, this reproductive cell is formed with reference to another kind of cell, without the concurrence of which other kind it is quite unable to perform its own proper function; while that other kind of cell is formed exclusively—and with an admirable adaptation of means to ends—for the purpose of aiding the proper function of the first kind of cell. This reciprocal purposive relation, with the results of the due carrying out of the thus related processes, are amongst the most wonderful phenomena of the whole domain of Biology.

One of the two reproductive elements here referred to is, as it were, passive, and awaits the advent of the more active element. The former is the female product; the latter is the product of the male.

In order, then, to effect reproduction, distinct SEXUAL ORGANS are required for the formation (secretion) of these two elements. But it is also evident that other organs are needed whereby the juxtaposition of these elements may be effected, and thus it is clear that the generative organs must be of two kinds: (1) *internal* organs, which concern the formation of these elements themselves, and (2) *external* organs, which concern their transmission and conjunction. These organs may be expected to be different in the two sexes, as is in fact the case, and thus we have to consider the external and internal generative organs, both of the male and of the female sex.

§ 20. The MALE GENERATIVE ORGANS of the cat consist, in the first place, of two glandular structures, the *testes* (which are the essential male organs, since it is they which secrete the male generative element).

Two tubes, one from each testis, called the *vasa deferentia*, open into that median canal, the *urethra*, which, as we have already seen, proceeds from the anterior orifice of the bladder. This canal also receives the products of certain accessory glandular structures, and proceeds to traverse that median external body, the *penis*, which latter serves as the channel of exit to the urinary secretion as well as to the generative products. As it leaves the bladder, the urethra is surrounded by one of the accessory structures before referred to, namely, the *prostate gland*. The other accessory glands, called *Cowper's glands*, are two small rounded bodies, placed one on each side of the urethra and in front of the prostate gland. Each vas deferens enters the urethra beside its fellow of the opposite side.

The *penis* is a conical body, mainly composed of fibrous tissue, but extremely vascular. Its tissue is of two kinds, arranged in three masses. One mass, median, ventral, and terminal in position, is called the *corpus spongiosum*, and immediately invests the urethra. The other kind forms two laterally and dorsally situated masses, called the *corpora cavernosa*, which are placed side by side, and form the bulk of the organ, which is attached by its root to the pubes and the part of the ischia nearest the symphysis pubis. The distal end of the organ is called the *glans*, and is an expansion of the corpus spongiosum. It is conical and pointed, and has at its ex-

tremity the external orifice of the urethra. The organ is suspended from the wall of the abdomen by a fold of integu which is inserted around the glans, forming what is calle *prepuce* (Fig. 115). When not sexually a the penis is bent backwards towards it tremity, a condition which makes th "retromingent." A small bone traverse midst of the distal part of the penis, rea almost to its extremity. The surface glans is beset with hard papillæ, the poi which are directed towards its base.

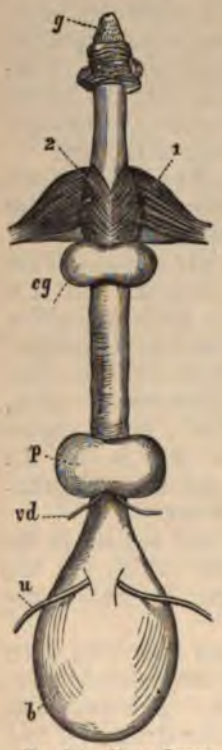


Fig. 115.—Male Organ of Generation—inferior surface.

u. Ureter.
vd. Vas deferens.
p. Prostate.
cg. Cowper's gland.
e. Erector penis muscle.
g. Glans penis.
b. Bladder.
1. One of the crura of the penis, with the ischio-cavernosus muscle upon it.
2. Accelerator urinæ muscle which invests the proximal, ventral part of the penis.

A portion of the external skin has been left attached round the base of the glans.

The corpora cavernosa and the spongiosum are each formed of a spongy of fibrous bands, called *trabeculæ*, cont elastic and muscular fibres as well as and arteries. In the intervals of these are highly distensible veins, into whi certain number of arteries directly oper is the capacity for temporary distensi means of such veins which causes these t to be spoken of as "*erectile*."

The *urethra* consists of a tube of m membrane invested by organic muscular It originates at the bladder, upon quitting it enters a gland to be shortly described prostate. In the floor of this prostatic p of the tube is a small, ridge-like promi called the *verum montanum*, in the mi which is a narrow, slit-like depression, n the *utricle* (*sinus pocularis*, or *vesica prost* at or within the margins of the openi which the seminal ducts, or vasa differ open into the urethra.

The term "membranous urethra" is a to that portion of the tube which emerges the prostate gland. Its membranous p soon succeeded by its "spongy portion, by the part which traverses the penis. Di the urethra is lined by squamous epith but elsewhere by epithelium of the colu kind.

The urethra of the male thus transmits the renal excretion (which traverses its length) and also the sexual secretion, traverses that part of it which is beyon entrance of the vasa differentia.

The *prostate gland* (Fig. 115, *p*.) is a voluminous, prom glandular structure surrounding the urethra at its exit fro bladder, and opening into that canal by numerous apertures

side of the verum montanum. It is made up of a number of small follicles, which open into its excretory canals, the apertures of which have just been mentioned. It is invested by a fibrous coat containing many organic muscular fibres. It secretes a fluid of a milky appearance.

Cowper's glands (Fig. 115, *c g*) are two large racemose structures of firm consistency, with a thick muscular envelope, placed one on each side of the urethra and a little beyond the prostate. Each opens by a single duct into the urethra at the root of the penis. These glands secrete a viscid fluid of unknown function.

The *scrotum* is that pouch of integument which is destined to contain the testes, which hang within it beneath the anus and behind the pelvis. Although this pouch (the scrotum) is single externally, an inner coat—the *dartos*—(consisting of vascular membrane with organic muscular fibres) forms two pouches, one for each testis. This coat is continuous with the fascia of the abdomen and thigh. Within it is a layer of membrane—the *spermatic fascia*—and other envelopes of connective tissue or muscular fibres—one delicate layer of the latter tissue forming what is known as the *cremaster* muscle.

Each testis is also enveloped in a pouch of peritoneum, called the *tunica vaginalis*, within which is the *tunica albuginea*—a dense, white, fibrous membrane, which immediately invests the testis itself.

§ **21.** The TESTES are the true male sexual glands, to which all the other male sexual organs are but auxiliary. Each testis is an oval body, which is suspended in the scrotal chamber by a cord—the *spermatic cord*—which passes forwards and inwards through the abdominal ring to the urethra. A conical, more or less separable body, known as the *epididymis*, lies dorsally and posteriorly upon the testis. As it is external to the testis itself, it is not invested by the tunica albuginea. One rounded end of the epididymis—called the *globus major*—is connected with the testis by certain ducts. The other more pointed end—the *globus minor*—is only united to it by connective tissue.

At that portion of the testis which is adjacent to the epididymis, the tunica albuginea is prolonged far down into the soft substance of the gland, forming a septum called the *mediastinum testis*, or *corpus Highmorianum*, which is situated in the middle of the testis. Many slender cords and lamellæ of connective tissue radiate from the mediastinum to the inner surface of the tunica albuginea, thus dividing that portion of the gland by imperfect partitions into conical interspaces, and helping to maintain the shape of the testis. The gland is richly supplied with blood-vessels, which ramify in the tunica albuginea and accompany its partitioning processes. Between these membranous imperfect partitions, lies the soft proper glandular substance of the testis, which consists of minute convoluted tubes, called *tubuli seminiferi*, because they are the immediate agents in seminal secretion. They are arranged in pyramidal aggregations or "lobules," respectively *invested* by the membranous imperfect par-

titions before mentioned. They converge and anastomose (tubes adjoining lobules anastomosing also) as they approach the medi tinum and epididymis till they are greatly reduced in number, wh they assume a comparatively straight course, and are called *tubuli recti*, or *vasa recta*. These traverse the mediastinum then form a network of tubes called the *vasculosum*, from which network other tub called *vasa efferentia*, arise, and these enter globus major of the epididymis.

Fig. 116. — Diagram showing the arrangement of the Tubes in a Mammalian Testis.

aa. Tubuli seminiferi, coiled up in the separate lobules.
b. Vasa recta.
c. Rete vasculosum.
d. Vasa efferentia, ending in the coni vasculosi.
l, *e*, *g*. Convoluted canal of the epididymis.
h. Vas deferens.
f. Section of the back part of the tunica albuginea.
i, *i*. Fibrous processes running between the lobes.
f to *s*. Mediastinum. In the cat the mediastinum is not on one side, as in the above figure, but is nearly in the middle of the testis.

The tubuli seminiferi are formed of connect tissue lined with a basement membrane epithelium which is never ciliated but c sists of nucleated granular corpuscles and cleated cells, which transform themselves i the male generative elements.

The *structure of the epididymis* is mu more simple than that of the testis. It c sists of an enormously long convoluted tu into the proximal part of which the v efferentia open.

These vasa efferentia, however, which nearly straight at first, do not remain so, each becomes much convoluted as it approac the canal of the epididymis, so that they fo a series of small conical masses called *vasculosi*, the apices of which are tur towards the testis and towards the apices the conical lobuli of that gland. They successively open into the canal of the epi dymis. This canal has its convolutions s ported by connective tissue (thus forming lob It increases in size towards the end of the glo minor, where it acquires thicker coats becomes the *vas deferens*. The vasa efferen are lined with ciliated epithelium, as is the case with the canal of the epididy Sometimes a small tube, called a *vas aberr* is given off from the commencement of the vas deferens. A small pedunculated structure in the vicinity of the head of epididymis is called the hydatid of *Morgagni*. A few convolu tubules (also near the head of the epididymis) are sometimes spo of as the *Organ of Giraldes* or *parepididymis*. These parts are q functionless remnants of a fœtal structure which will be noti in the chapter on Development.

The vas deferens—the continuation of the canal of the epididy —is at first much convoluted, but becoming straight extends up inner side of the epididymis, and thence upwards beside the sperm artery which goes to the testis, and the spermatic veins which le it,—these vessels, with the vas deferens and the tissues which u

them all together, forming the *spermatic cord* before referred to. The vas deferens is made of connective tissue enclosing a muscular coat, the inside of which is mucous membrane, lined internally with columnar but not ciliated epithelium. The two vasa deferentia open into the urethra, as before described.

§ 22. The special secretion of the testis consists of certain *spermatic filaments* or SPERMATOZOA, which by their activity remind us of detached cells of ciliated epithelium. They are not however the equivalents of such cells, but of subdivisions of such cells. Each spermatozoon consists of an oval flattened part called the "head" or "body," and of a long and very slender filamentary "tail."

Each spermatozoon is a peculiarly shaped cell of protoplasm, containing a nucleus. The oval portion or head consists of the nucleus enveloped in an extremely delicate layer of protoplasm, which protoplasm is continued on to form the filamentary tail.

Fig. 117. — SPERMATOZOA OF THE CAT, MAGNIFIED 320 DIAMETERS, AND THEN ENLARGED THREE TIMES.

The spermatozoa are not the immediate product of the testicular tubuli; these first produce "sperm-cells" or "*spermospores*," which constitute the epithelium lining the tubuli. From these cells the spermatozoa appear to be formed by subdivision of the nucleus of each spermospore; the divisions of the nucleus forming the main part of the head of each spermatozoon, which is completed from the non-nuclear substance of the dividing spermospore.

The vibratile, lashing action of the spermatozoon, only takes place when it is fully developed. It will retain its power of movement for some hours after its removal from the body if immersed in a suitable fluid. By its lashings it effects a locomotive movement, and it is thus admirably enabled to advance towards its proper destination. Without the aid of these spermatic filaments no reproduction of the cat species can take place.

§ 23. The FEMALE GENERATIVE ORGANS may, like those of the male, be divided into (1) the *external*, and (2) the *internal* organs—the latter being the essential sexual parts. The functions of the female organs are, however, more complex than those of the male. The latter are destined to simply form and discharge their products, but the female organs have not only to do this but also to receive the male product and to protect and further that developmental action which is initiated by the junction of that male product with their own. The female organs consist, in the first place, of two glandular structures, the *ovaries*, which secrete the female generative product, the *ova*. Two tubes, one for each ovary, called the *Fallopian tubes*, open into a median tubular structure, the *uterus*, which is continued onwards to the exterior by the help of another tube—the *vagina*, immediately external to which is the *uro-genital* chamber or *vestibule*, which is the most external portion of the whole apparatus, and which opens on the surface of the body a

little in front of the anal aperture. At the anterior part of the vestibule is the opening of the urethra, which is continued to this point from the bladder. Just in front of the external opening of the urethra is a small body called the *clitoris*, whence two folds—the *labia*—proceed backwards (surrounding the external vaginal aperture), beneath which (one on each side) are two glands, called those of *Bertholin*, the ducts of which open into the vestibule.

The *urethra* of the female is thus but a very short tube. It transmits the renal excretion only, the sexual excretion not passing through it. The vestibule represents the prostatic part of the male urethra, but there is no part answering to the spongy portion of the latter. There is no such part, because the clitoris (which is the rudimentary representation in the female, of the penis of the male, and is similarly formed of two corpora cavernosa, a corpus spongiosum and a very small ossicle) is imperforate and not traversed by the urethra.

There is no representative, in the female, of the prostate gland of the male, but the "Cowper's glands" are represented by the "glands of Bertholin," which have a muscular envelope like their analogues in the other sex.

There is no scrotum, because the ovaries (which are the analogues of the testes) are enclosed within the abdominal cavity. Nevertheless the scrotum is represented by the labia which bound the external aperture on each side.

We now come to parts in the female which are hardly represented in the male. We saw in the latter that there was a slight depression (the "utricle" or "sinus pocularis,") in the floor of the prostatic portion of the urethra and between the entrance into it of the vasa differentia. In the female, this small depression is represented by a deep cylindrical cavity consisting of two successive parts, the vagina and the uterus, but no tubes open beside it corresponding to the vasa differentia of the male cat. The *vagina* (which opens posteriorly into the vestibule, while anteriorly it opens into the uterus,) is formed of fibrous tissue and organic muscular fibre lined with mucous membrane, with numerous papillæ and follicles, and coated with squamous epithelium. Towards the vestibule its muscular fibres arrange themselves as a sphincter. A few ridges (*rugæ*) extend along the length of its inner surface and terminate abruptly at a transverse circular prominence (which may be a distinct fold or may be almost indistinguishable) called the *hymen*, which marks off the commencement of the vagina from the more externally situated vestibule.

The *uterus* (Fig. 105, *ut* and *c*) is a short muscular bag with two very long, posteriorly diverging, branches or lateral continuations—the cornua—which extend horizontally forwards in the abdominal cavity.

Its commencement, the *os tincæ*, projects prominently into the hinder part of the vagina, and is beset with numerous short

papillæ. Anteriorly the cornua terminate by receiving the openings of the Fallopian tubes.

The organ is formed of a mass of organic muscular fibre and fibrous tissue (richly supplied with vessels and nerves) and is lined with mucous membrane beset with simple tubular glands, which upon its interior surface is coated with columnar and ciliated epithelium.

The uterus is the organ destined to shelter and nourish the ova from shortly after their impregnation till the litter is brought forth. This period is that of "pregnancy," and during it the organ increases enormously in size and capacity and in the quantity of muscular tissue it contains.

The size of the uterus therefore varies extremely, according to whether it does or does not contain ova in process of development, and according to the development which such ova may have attained. The time of carrying the kittens within it, *i.e.*, the *period of gestation*, having come to an end, the uterus begins to undergo powerful contractions till its contents are expelled in the act of giving birth, or *parturition*. This act accomplished, the organ begins again to diminish, many of its muscular fibres undergo a transformation into fatty matter and are then absorbed, and it soon returns nearly to the size which it had before impregnation.

The uterus is held in place, partly by its continuity with the Fallopian tubes and vagina, partly by ligaments called respectively "broad," "ovarian" and "round." The *broad ligaments* are great lateral folds of peritoneum which embrace the uterus with its cornua and the Fallopian tubes and ovary. The *ovarian ligaments* are short fibrous cords which extend one from the end of each uterine cornu to the adjacent ovary. The *round ligaments* are two delicate fibrous cords which pass one from each of the sides of the uterus to the brim of the pelvis.

The *Fallopian tubes* (Fig. 105, *f*,) have been already mentioned as extending along within the folds of the broad ligament to the extremity of the cornua of the uterus—one Fallopian tube opening into each cornu after following a much convoluted course.

At its opposite extremity each Fallopian tube ends in an expanded, trumpet-like termination surrounded by certain irregular processes or *fimbriæ*, one of which, longer than the others, is attached to the adjacent ovary. The fimbriated and expanded end of the Fallopian tube has been named the *morsus diaboli*. The cavity within the Fallopian tube is extremely minute, and opens externally in the midst of its fimbriated extremity.

Each Fallopian tube is, as has been said, coated externally with peritoneum; within this is a layer of longitudinal organic fibres, and within this again a circular layer. Within all else is the mucous lining (which forms longitudinal internal folds,) coated with columnar and ciliated epithelium. At the orifice of the Fallopian tube the mucous membrane which lines its interior becomes actually continuous with the peritoneal coat which invests it externally. Thus, in the female (unlike the male) the perito-

neum is not a shut sac but has two distinct perforations, the mouths of the Fallopian tubes, which indirectly place its cavity in connection with the external surface of the body.

§ **24**. The OVARY is the essential secreting organ of the female sex, corresponding to the testis of the male. There are two such bodies, one on each side, as there are two testes, but, unlike the latter, the ovaries are each a completely closed sac or follicle, and, though each has its excretory duct—the Fallopian tube—this duct has no permanent connexion with its gland (as the vas deferens has

Fig. 118.—SECTION OF THE PREPARED OVARY OF THE CAT—MAGNIFIED SIX DIAMETERS.

1. Outer covering and free border of the ovary.
1'. Attached border.
2. The ovarian stroma, presenting a fibrous and vascular structure.
3. External fibro-nuclear substance.
4. Blood-vessels.
5. Ovigerms in their earliest stages, lying near the surface.
6. Ovigerms which have begun to enlarge, and to pass more deeply into the ovary.
7. Ovigerms, round which the Graafian follicle and tunica granulosa are now formed, and which have passed somewhat deeper into the ovary, and are surrounded by firm fibrous stroma.
8. More advanced Graafian follicle, with the ovum imbedded in the cells of the proligerous disc.
9. The most advanced follicle, containing the ovum, and approaching the surface.
9'. A follicle from which the ovum has accidentally escaped.
10. Corpus luteum, presenting radiated columns of cellular structure.

with its testis), but only a temporary one. The ovary is of an oval shape (like the testis). It lies deeply in the dorsal and lateral part of the abdominal cavity, hidden by the intestines, and enveloped in a fold of peritoneum which forms its outer coat. The inner end of the gland is attached to the uterus by a dense cord, already mentioned as the *ligament* of the *ovary*. At the anterior border of the gland is a depression called the *hilus*, where the blood-vessels enter, and which is the only part not invested by the peritoneum. Beneath the outer or serous coat of the ovary is its second or proper covering, the *tunica albuginea*, often compared with the same part of the testis. It serves to maintain the organ in shape, but really is but a condensed part of what is beneath it, namely, the proper tissue—the *stroma*, or *parenchyma*, of the ovary. This substance is of a pink, or red, colour (from the number of vessels it contains), and is made up of connective tissue, with nerves

blood-vessels, and some muscular fibres. It has an outer epithelial covering, and contains embedded vesicles of various sizes—called *Graafian follicles*—containing the ova, or true female sexual product.

In the stroma of the ovary there is but little fibrous connective tissue. It is made up mainly of large spindle-shaped cells,* which surround the Graafian follicles, being arranged concentrically about them.

Upon dividing the ovary, vesicles of various sizes are seen within,

Fig. 119.—Portion of the Section of the prepared Cat's Ovary, represented in the preceding figure, more highly magnified.

1. Outer covering of the ovary.
2. Fibrous stroma.
3. Superficial layer of fibro-nuclear substance.
3'. Deeper parts of the same.
4. Blood-vessels.
5. Ovigerms forming a layer near the surface.
6. One or two of the ovigerms sinking deeper, and beginning to enlarge.
7. One of the ovigerms further developed, now enclosed by a prolongation of the fibrous stroma, and consisting of a small Graafian follicle, within which is situated the ovum covered by the cells of the discus proligerus.
8. A follicle further advanced.
8'. Another which is irregularly compressed.
9. The greater part of the largest follicle—in which the following parts are seen: *a*, cells of the membrana granulosa lining the follicle; *b*, the reflected portion, named discus proligerus; *c*, vitellus or yelk part of the ovum, surrounded by the zona pellucida; *d*, germinal vesicle; *e*, germinal spot.

and these are much more numerous in the very young animal than in the adult.

These vesicles, or "*Graafian follicles*," are naturally spherical or oval, and have three coats. The first and most external of these, the *tunic of the ovisac*, or *tunica fibrosa*, is a fibrous, vascular membrane, containing oval nuclei, but destitute of oil globules. The second coat is the *ovisac*, formed of connective tissue, rounded cells, and minute oil globules. The third coat (if it should be really recognized as distinct) is the *membrana granulosa*, consisting

* See Klein and Noble Smith's Atlas of Histology.

of a stratum of nucleated cells lying in close contact with the inner surface of the ovisac. Enclosed within these layers is a clear and colourless albuminous fluid, and a small, rounded body, embedded in a cellular mass, the *discus proligerus* or *cumulus*, on the inner surface of the membrana granulosa. This rounded body is the *ovum*—the special female sexual element. The larger Graafian vesicles are found at, or near, the surface of the ovary, and it has been found that they approach the surface as they develop. They are indeed primitively formed at the periphery, but they subsequently sink inwards, and afterwards return once more to the surface. At first the Graafian vesicle is but the envelope of the minute ovum it contains. It subsequently increases, so as to exceed in size the contained ovum to a greater and greater, and ultimately to a very great, degree.

§ **25.** The OVUM is a minute spheroidal mass of protein substance, about the $\frac{1}{180}$ to $\frac{1}{120}$ of an inch in diameter. It consists of an external tough, elastic, and relatively thick tunic, the *zona pellucida*, which is quite transparent and structureless, though apparently perforated by many excessively minute pores. Externally the zona pellucida is invested by a layer of epithelial cells, the *tunica granulosa*, which is embedded in the cellular mass, the *cumulus*, which connects the ovum with the innermost coat (or membrana granulosa) of the Graafian vesicle. Within the zona pellucida is the yelk mass (as some say enclosed within a distinct, but extremely delicate, membrane) of protoplasm and granular matter, with oil globules, but having within it a nucleus termed the *germinal vesicle*, about the $\frac{1}{120}$ of an inch in diameter, and enclosing a minute opaque body or nucleolus, known as the *germinal spot*, which is from the $\frac{1}{3500}$ to the $\frac{1}{2500}$ of an inch in diameter.

Fig. 120.—THE OVUM, GREATLY MAGNIFIED.

Its outer coat is the zona pellucida, which shows a radiated linear structure. Within this is the yelk substance, with granules and small oil globules; towards one side is the large germinal vesicle containing the germinal spot.

Beside the ovary, within the folds of broad ligament, are certain small tubules, which together constitute what is called the *parovarium*. This small body is analogous to the organ of Giraldès, found in some male animals. Connected with the parovarium is a delicate, cylindrical structure called *Gaertner's duct*, which runs from the parovarium down the side of the body of the uterus, when it ends blindly.*

A small pedunculated body in the vicinity of the parovarium, or of the mouth of the Fallopian tube, is called a *hydatid* in the female, as are corresponding structures in the male.

The *function of the ovary* is of course mainly to secrete ova, but the formation of the Graafian vesicles, in which the ova are

* Mr. Alban Doran has ascertained these points by careful dissections.

contained, must also be reckoned as a part of its function. The development of ripe ova—or *ovulation*—begins to take place in the first year of the animal's life, and is thenceforth continued till the bodily decay of age sets in.

It takes place at frequent intervals,* and culminates in the rupture of one or more Graafian vesicles, with the discharge of the ovum or ova from the surface of the ovary through its peritoneal coat into the peritoneal cavity. This process is generally accompanied with more or less constitutional disturbance, and an increased supply of blood to the generative organs. By a wonderful and quite unexplained process of reflex action, the rupture of a Graafian vesicle is accompanied by a spontaneous application of the fimbriated end of the Fallopian tube to the place of rupture. In this way the discharged ovum, instead of being cast loose into the peritoneal cavity, is received into the mouth and canal of the Fallopian tube, and so conveyed onwards, by its ciliated lining, to the cavity of the uterus. The walls of the ruptured Graafian vesicle then increase in substance, and thus give rise, for a time, to a yellowish mass termed the *corpus luteum* (Fig. 118, [10]).

Simultaneously with the constitutional disturbance just referred to, the sexual appetite is inflamed, and the animal becomes "at heat."

The formation of the ova, unlike that of the spermatozoa, does not take place in distinct tubes,† but in the seemingly non-tubular substance or stroma of the ovary. The process of the formation of the ova is so different from that of spermatozoa, and is so closely connected with embryonic conditions, that its description is more in place under the head of development. Nevertheless it may be here observed that each ovum is a modified and enlarged cell of the epithelial tissue of the ovary, which is thus, as before pointed out, not the equivalent of a spermatozoon, but of a "sperm-cell" or "spermospore," which is the parent of various spermatozoa. The incipient ovum—or ovigerm—becomes surrounded by other smaller cells, which subsequently, by multiplication and separation form both the "tunica granulosa" of the ovum and the "membrana granulosa" lining the Graafian follicles—fluid gradually forming and greatly increasing between these at first closely juxtaposed layers. The outer envelope of the Graafian follicle appears to be formed by other epithelial cells, and by a special growth of the ovarian stroma around the developing ovum.

* It is difficult to ascertain how often, as the adult unimpregnated female cat often seems to be almost continually ready for reproductive activity.

† Whether the composition of the ovary and the formation of ova are essentially "tubular," is a question which cannot yet be regarded as finally settled; but the wide divergence of form which exists between the mature sexual glands of the two sexes is manifest and indisputable. For some recent observations made with reference to this obscure question, see a paper by Mr. E. A. Schäfer, F.R.S., in Pro. Roy. Society, 1880, p. 245.

CHAPTER IX.

THE CAT'S NERVOUS SYSTEM AND ORGANS OF SENSE.

§ 1. We have now to consider that system of parts which ministers not merely to the processes of organic life, but also to motion, sensation, and cognition. It may therefore be considered as the highest system of parts of which the cat's body is made up. It is so closely connected with motion, and motion is so closely connected with sensation, that these functions would have been here treated of together but for three reasons: The first reason was that the consideration of the muscles, as forming so large a part of the body, could not conveniently be postponed; secondly, the intimate relation of the muscles to the bony levers they move, made it desirable to consider them immediately after the description of the skeleton; and thirdly, the study of the nervous system can hardly be profitably pursued till acquaintance has been made with all the main organs and parts to which the various nerves are distributed. Such an acquaintance has now been made, and the nervous system remains alone for our ultimate consideration, both as to its structure and as to its functions —the most conspicuous of the latter being sensation. All forms of merely physical activity, such as light, heat, chemical change, &c., are indeed separated by a gulf from the activities of organic growth and reproduction, but a gulf hardly less marked divides these latter faculties from one so altogether peculiar and *sui generis* as is the wonderful power of *feeling* and *cognition*.

But although the nervous system is that which MINISTERS TO SENSATION—that without which we have no evidence that sensation is even possible—nevertheless such a definition of its functions would be very incomplete. The nervous system is the immediate cause of motion, and performs, as we shall see, an intermediate part between the organism containing it, as a whole, and the environing world, since it receives influences from the latter which may excite correlative activities in the organism without, as well as with, the accompaniment of sensation.

It has been before said that an organism is a body in which each part is reciprocally end and means. In animal organisms, this reciprocity is generally ministered to and effected by the agency of the

nervous system, and this reciprocal activity is mainly effected without "feeling" coming into play.

Thus the nervous system may be DEFINED as the GREAT CO-ORDINATING SYSTEM of the body; co-ordinating the action of the parts of the body one with another, co-ordinating the action of such parts with relation to surrounding influences and conditions, and also co-ordinating the action of the body as a whole with relation to such influences and conditions—the activity of the nervous system being more or less frequently accompanied by acts of sensation.

§ 2. SENSATION is incapable of definition, since to be understood it must be experienced, and every man must know what it is to have a feeling who knows anything whatever, as "sensations" are with us the indispensable antecedents of ideas, and therefore of all knowledge. Sensation, however, may be described as a special and altogether peculiar vital organic activity, which accompanies certain actions of the nervous system occurring under the requisite conditions.

§ 3. That system of parts, the nervous system, the nature of which has just been defined, is made up, like the skeleton, of two great divisions, one AXIAL, the other PERIPHERAL. Besides these, that part of the peripheral system which especially supplies the viscera, is commonly reckoned as distinct, under the name of the SYMPATHETIC system. The whole consists of a peculiar tissue (to be shortly described), forming a white or grey pulpy mass in the form of bulky aggregations, and of cords or threads, which radiate in all directions from such aggregations.

The *axial* part of the nervous system is that bulky aggregation of nervous or neural matter, which occupies the cranial cavity and the neural canal of the vertebral column (Fig. 2, *n*), that is to say, it is the brain and spinal cord which are together spoken of as the *cerebro-spinal axis*.

The *peripheral* part of the nervous system is that system of cords or threads of neural matter which are called *nerves*, and which proceed out from the cerebro-spinal axis to all parts of the body. Scattered amongst them every here and there are certain aggregations of nervous matter—in rounded or irregularly-shaped masses of various sizes—called *ganglia*. That portion of the peripheral part of the nervous system called the *sympathetic* (and which, as just observed, is specially distributed to the viscera) differs somewhat from the rest as to its minute structure.

§ 4. NERVOUS TISSUE is a soft, nitrogenous substance of very complex chemical composition. It is reducible into water, albuminoid matter, fatty and extractive matters, and sundry salts. Different parts of it contain from 73 to 85 per cent. of water, 7 to 10 per cent. of albuminoid matter, and from 5 to 15 per cent. of fat.

The fatty matters consist of cerebric, glycero-phosphoric, and palmitic acids, with olein, margarin, palmitin, and cholesterin. From brain-ash the following percentage of different substances has been obtained. Phosphate of potash, 55·24; phosphate of soda,

22·93; phosphate of iron, 1·23; phosphate of lime, 1·62; phosphate of magnesia, 3·4; chloride of sodium, 4·74; sulphate of potash, 1·64; free phosphoric acid, 9·15; and silicic acid, 0·41.

The STRUCTURAL ELEMENTS of nervous tissue are mainly of two kinds: (1) *fibres*, and (2) *nerve-cells* or *corpuscles*. The former of these elements makes up the bulk of the peripheral part of the nervous system, while the corpuscles abound in its axial portion and in its scattered ganglia.

The NERVE FIBRES are again divisible into two kinds: (1) the *white* or *tubular* nerve fibres, and (2) the *grey* or *pale* fibres.

The *white fibres*, which form the bulk of all the nerves except those of the sympathetic system, are nearly cylindrical filaments

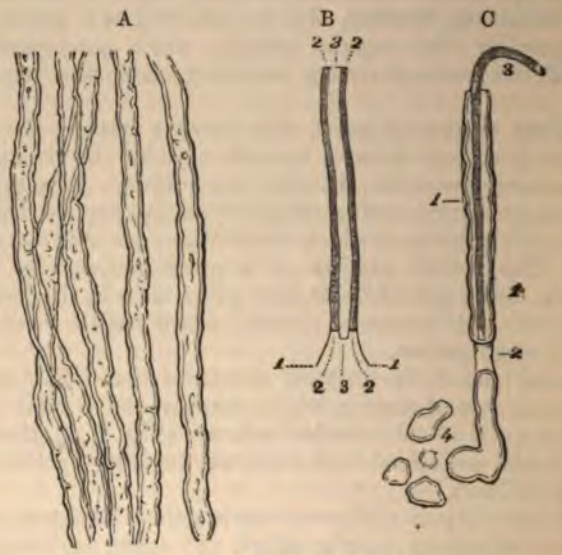


Fig. 121.—WHITE NERVE FIBRES.

A. White or medullated nerve-fibres, showing their sinuous outline and double contours.
B. Diagram showing the parts of a medullated fibre, viz.:
1—1. *Primitive sheath.*
2—2. The white substance, or *medullary sheath.*
3. The axis-fibre, or axis-cylinder—sometimes called the primitive band.
C. Diagram intended to represent appearances occasionally seen in the tubular fibres, viz.
1—1. Membrane of the tube, seen at part where the white substance has separated from it.
2. A part where the white substance is interrupted.
3. Axis projecting beyond the broken end of the tube.
4. Parts of the contents of the tube which have escaped.

which, during life, seem composed of a clear, oily, semi-fluid substance, but after death, appear as composed of a delicate structureless outer membrane—the primitive sheath (like the sarcolemma of muscle fibre), provided with large nuclei, and containing fatty fluid termed the *medullary sheath* or *white substance of Schwann*, through which runs a thin central thread of albuminoid matter called the *axis cylinder*. The largest of these white nerve-fibres has a diameter of about *the* $\frac{1}{300}$ of an inch, but some of only $\frac{1}{2000}$. They may be larger

at other parts of its course than at their origins or terminations. The terminations of nerves, whether they end peripherally or centrally, are often spoken of as "*end organs.*" White nerve-fibres run side by side in a bundle, bound together by delicate connective tissue, which also forms a sheath for them called the *neurilemma.* In spite of their close proximity these fibres have never been observed to anastomose, nor have single fibres been seen to branch till within a microscopic distance of their termination. This ultimate branching may be due to the axis cylinder really consisting of distinct fibrils bound together, as a longitudinal striated appearance they sometimes exhibit would seem to indicate. On the other hand, by the action of nitrate of silver they may be made to exhibit a transverse striation like that of muscular fibres, so that the meaning of either of these appearances is problematical.*

The *grey or pale fibres* are chiefly found in the nerves of the sympathetic system, but the olfactory nerves also are entirely composed of them. They are from $\frac{1}{8000}$ to $\frac{1}{6000}$ of an inch in diameter, and are devoid of that apparent distinctness of parts characterising

Fig. 122.—NERVE-CELLS FROM THE OUTER GREY PORTION OF THE CEREBELLUM, MAGNIFIED 260 DIAMETERS.

a a. Cells, each containing a nucleus, with a distinct nucleolus.
b b. Simple unbranched processes.
cc', dd'. Branches radiating in different directions, and ramifying in various degrees.

the white fibres. They appear translucent, homogeneous, and slightly granular, and exhibit at intervals oblong nuclei, which have been supposed to belong to the sheaths of such nerves.

Nerve cells, or *nerve corpuscles*, are very different in appearance from nerve fibres. Each consists of a round, oval, pyramidal, club-shaped, pear-shaped, or many-cornered microscopic body, formed of protoplasm, and which may appear clear or granular according to circumstances (perhaps of observation), and which contains a nucleus with one or more nucleoli. Some of these cells are devoid of processes

* There now appears to be reason to suppose that the axis cylinder is really segmented.

(and this, for the most part, is their form in ganglia), many have but one, very many have two or more—conditions denoted by the terms "apolar," "unipolar," "multipolar." Sometimes a process from one cell may be seen to join a process from another cell. Sometimes a process from a cell appears to continue on as the axis cylinder of a nerve. Nerve fibres certainly often appear to end close to cells, but there is as yet much dispute as to the connexions between them and between the processes of different cells. A desire to serve a particular theory has certainly given rise to much exaggeration as to the amount—often even as to the existence—of such connexions. In most cases the processes seem simply to ramify and become finer and finer till they cease to be distinguishable.

Neuroglia is a substance which immediately surrounds the fibres and cells, and which has been supposed to be a peculiarly modified form of connective tissue. It is a semi-solid matrix which appears granular, though it may really be structureless—its granular appearance being the result of a coagulation.

Such being the nature and minute constituents of the nervous system, its great mass, the cerebro-spinal axis, is said to be made up of *white* and of *grey* nervous matter. The former consists of white fibres only, while the grey matter consists very largely of nervous corpuscles, and is more vascular. Throughout the whole length of the *spinal part* of the cerebro-spinal axis the grey matter lies towards the middle of the whole nervous mass, the white matter being external. In the *cerebral part* of the same axis, however, the grey matter extends from within and expands over its surface. Although the cerebro-spinal axis is very vascular, yet the arteries and veins which traverse it are very minute.

5. The cerebro-spinal axis is invested and protected by three MEMBRANES, enclosed one within the other.

The first of these is called the *dura mater*, and is composed of thick, dense, inelastic fibrous membrane, free and smooth on its inner surface, but closely connected externally, in the skull, with the inner surface of the cranial bones, of which it forms the periosteum.

In the spinal column it does not constitute the periosteum of the neural canal, but is only connected with the inner surfaces of the vertebræ by loose areolar tissue and fat, and by slips of fibrous membrane.

In the cranium the dura mater sends inwards two folds of membrane.

The first of these is longitudinal, and is called the *falx cerebri*, and extends from the front of the skull to the occiput, depending from the middle of the cranial vault.

The second fold is the *tentorium*, which extends forwards and downwards from the posterior margins of the parietal bones. It is also attached to the upper edge of the petrous portion of each temporal bone. The tentorium, as we have seen in the third chapter, becomes ossified in the adult cat.

The second of the three membranous envelopes is called the *pia mater*, and is a very delicate, vascular membrane, which is closely

applied to the surface of the cerebro-spinal axis and conveys its minute arteries to it (Fig. 123, *c*). It is thicker and less vascular on the spinal cord than on the brain. At the roots of the nerves it becomes continuous with the neurilemma.

The third membrane is called the *arachnoid*, and is a serous membrane forming a closed sac and containing a fluid.

The outer, or parietal, wall of this sac consists of a layer of flattened and nucleated, polygonal, epithelial cells, intimately connected with the dura mater (both cranial and spinal) external to it.

The inner, or visceral, wall of the sac is a distinct membrane investing, but not intimately, the pia mater, the foldings of which it does not follow—a space, the *sub-arachnoid space*, existing between them and containing a watery secretion. A series of attachments, called the *ligamentum denticulatum*, connects the spinal part of the arachnoid to the spinal dura mater—one existing, on each side, between each pair of nerves issuing from the spinal nervous axis.

Fig. 123.—BRAIN IN SITU, THE UPPER PART OF THE SKULL BEING REMOVED.

On the right side all the membranes are removed. The pia mater (with its vessels) remain on the left side.

c. Cerebrum invested by pia mater.
ce. Cerebellum.
cr. Crucial sulcus.
f. Frontal bone.
fs. Frontal sinus.
i. Superior lateral gyrus.
m. Middle lateral gyrus.
s. Inferior lateral gyrus.
z. Zygoma.

§ 6. The SPINAL CORD, or MYELON, is the more or less cylindrical mass of nervous matter of varying dimensions, enclosed within the neural canal of the spinal column, extending backwards from the margin of the foramen magnum of the skull.

It remains of considerable size thence backwards till it reaches the hinder part of the lumbar region and sacrum, where it contracts to a slender filament, the *filum terminale*, which extends on into the tail.

The general form of the spinal cord is cylindrical, but it is a little flattened from above downwards. It becomes somewhat broadened out in two places. The first of these, called the *cervical enlargement*, extends from the third cervical to the first dorsal vertebra. The second, termed the *lumbar enlargement*, is situated at the last dorsal vertebra, whence the myelon tapers till it ends in the "filum terminale."

The cord is traversed by a deep median fissure both below and

dorsally, of which the first or "*anterior** *median fissure*" is the more distinct, and a process of the pia mater is prolonged into it which is not the case as regards the *posterior median fissure*.

Each lateral half of the spinal cord is also marked by two longi-

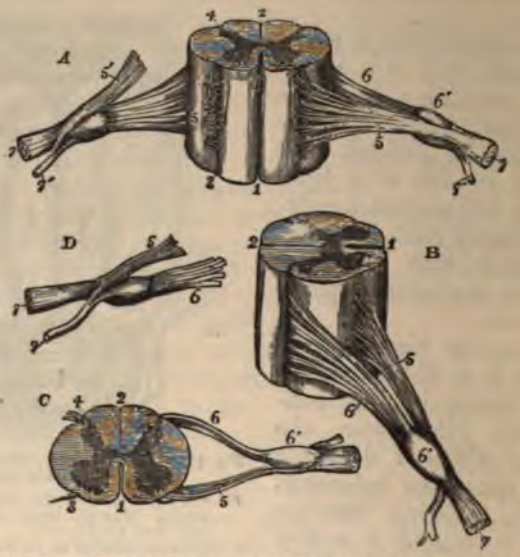


Fig. 124.—Different views of a portion of the Spinal Cord from the Cervical Region, with the Roots of the Nerves, enlarged (Allen Thomson).

In *A* the ventral or anterior surface is shown, the anterior nerve-root of the right side being divided; in *B*, a view of the right side is given; in *C*, the anterior or upper surface is shown; in *D*, the nerve-roots and ganglion are shown from below.

1. The anterior median fissure.
2. Posterior median fissure.
3. Anterior lateral depression, over which the anterior nerve-roots are seen to spread.
4. Posterior lateral groove, into which the posterior roots are seen to sink.
5. Anterior roots passing the ganglion.
5'. In *A* the anterior root divided.
6. The posterior roots, the fibres of which pass into the ganglion, 6'.
7. The united or compound nerve.
7'. The posterior primary branch, seen in *A* and *D* to be derived in part from the anterior and in part from the posterior root.

tudinal furrows, of which the posterior, or *posterior lateral fissure*, is far the more distinct. These furrows serve to define what are called the "columns" which make up the cord—each lateral half of it being divided into an *anterior*, a *lateral*, and a *posterior* column. Nervous fibres (the roots of the spinal nerves) pass out at the anterior and posterior lateral furrows.

As the nerves which so pass out traverse the intervertebral foramina of the spinal column, and as the spinal cord stops (as has been said) much short of the hinder termination of the vertebral neural canal, it comes to pass that the nerves which pass out at the sacral foramina have run back for a longer or shorter distance within

* The terms "anterior" and "posterior" refer to human anatomy, which originated these names - applicable to man with his upright attitude, but unfortunate as applied to a quadruped like the cat.

the neural canal till they come to the foramina appropriated to them respectively. Thus a bundle of nerves passes backwards in the hinder part of that canal, on each side of the filum terminale, and the whole bundle of such fibres goes by the name of the *cauda equina*.

The spinal cord is composed principally of white fibres, while the grey matter within it is so aggregated as to present the appearance, in transverse sections, of two crescentic masses with their convexities adjacent and placed one in each lateral half of the cord (Fig. 124, *C*).

Each grey crescent ends in what is called an anterior and posterior horn, which approach respectively to the anterior and posterior lateral furrows. The posterior horn is long, with a narrow end. The anterior horn is shorter and thicker, with a rounded end.

Fig. 125.—LATERAL VIEW OF THE BRAIN.

F. Frontal lobe.
T. Temporal lobe.
ol. Olfactory lobe.
m. Medulla oblongata.
cb. Cerebellum.
v. Pons Varolii.
S. Sylvian fissure (the Sylvian fissure is the sulcus which passes backwards and somewhat upwards from the spot to which the letter *S* has been made to point.
s. Superior external gyrus.
m. Middle external gyrus.
i. Inferior external gyrus.
o. Supra-orbital sulcus.
c. Crucial sulcus.
h. Hippocampal gyrus. To the right of *h* is seen the cut end of the left optic nerve.

The two crescents are united together by a band of grey tissue running across transversely at the bottom of the posterior median fissure, and called the *grey* or *posterior commissure*. Another band of white tissue also runs transversely across at the bottom of the anterior fissure, and is called the *white* or *anterior commissure*.

A minute central canal runs backwards along the whole length of the spinal cord and into the filum terminale. It traverses the posterior or grey commissure, and is lined with a layer of cylindrical cells of ciliated epithelium. It is called the *canalis centralis*.

§ 7. The BRAIN, or ENCEPHALON, is that enlarged part of the nervous centres which is contained within the cranium and is enveloped by the three membranes already described. It is a mass of soft, but more or less solid, matter which fills up the whole cranial cavity, fitting into all those depressions which we have found to exist in the floor and other parts of that cavity. It consists of two large but very unequal parts, termed respectively the *cerebrum* and cerebellum,

and of smaller portions which connect these together and with the spinal cord, of which the brain (as has been already observed) is, as it were, the greatly enlarged, anterior termination.

The largest portion of the brain by far is the cerebrum; which is made up of two great masses termed *hemispheres*, placed side by side, and forming the anterior, upper, and lateral parts of the brain. Each cerebral hemisphere is considered to principally consist of two main parts or *lobes*. The more anterior of these is called the *frontal lobe*, and it includes nearly the anterior half of each hemisphere. The other is the *temporal lobe*, which forms a lateral and inferior prominence, which lies in the "internal temporal fossa" on the inside of the skull.* The posterior, inner, and upper portion of each hemisphere may be regarded as a slightly and indistinctly developed *posterior lobe*. The hemispheres are united with the hinder part of the *brain mainly as follows*:—The spinal cord on entering the skull becomes modified and takes the name of the *medulla oblongata*, and this is the hindmost part of the base of the brain. Continuing forwards the medulla divides into two large branches, the *crura*, which pass respectively one into each cerebral hemisphere, and thus connect them with the spinal column. On the dorsal surface of this continuation of the spinal cord into the skull, is placed the cerebellum (or second largest portion of the brain), while on its ventral surface is a prominent mass of transversely disposed fibres—the *pons Varolii*—which, as it were, wraps round the anterior end of the medulla on its under surface, and covers in ventrally, its divergence into the crura, which thus appear to issue from above the anterior margin of the pons. The brain contains within it certain cavities, which, with one exception, are the greatly enlarged and complexly shaped continuation forwards of that minute canal (the "canalis centralis") which we have seen to traverse the spinal cord for its whole length. The different portions of this curiously expanded cavity within the brain are termed *ventricles*, and they are lined by a delicate epithelial membrane termed the *ependyma*. This ventricular cavity extends forwards beneath the cerebellum and above the pons Varolii, and as it is mainly bounded below (in front of the pons Varolii) by the crura and certain other structures between them, so it is bounded above (between the cerebellum and the cerebrum) by a variously formed layer of brain substance, which will be described further on and which constitutes a minor bond of union between the cerebrum and the parts behind it. From the anterior and lower part of each hemisphere there proceeds forwards a body which consists of a cylindrical prolongation of brain substance, ending in a rounded expansion. These two bodies are called the *olfactory lobes*.† They lie within the olfactory fossa of the cranium.

* See *ante*, p. 83.

† In human anatomy they are often called the olfactory *nerves*. But in fact the true olfactory nerves come from them.

On removing the upper part of the skull (with the ossified tentorium and the unossified part of the dura mater) the surface of the brain comes into view as an ovoid, convex mass, consisting of two large anterior portions, with a few large contorted prominences on their surface, and a smaller posterior part marked with numerous small transverse folds or furrows. The two large anterior portions are the cerebral hemispheres, the median, posterior part is the cerebellum—the anterior part of the upper surface of which is overlapped by the hinder portions of the cerebral hemispheres. The anterior ends of the two olfactory lobes are also to be seen projecting in front of the middle of the anterior end of the cerebrum (Fig. 126, *ol*). The median line which divides the cerebrum into its two lateral halves, or hemispheres, is called the *great* or *median longitudinal fissure*. The smooth, contorted prominences on the surface of the cerebrum, are called the *convolutions* or *gyri*, the depressions which separate them are termed *sulci*, or *fissures*. These gyri and sulci are distinguished by definite names; but it will be better to defer their description till a further acquaintance has been made with the brain as a whole, and with all its main constituent portions. The *pia mater* so closely invests the brain that it passes down not only into the great longitudinal fissure, but also into all the sulci of the cerebrum and into the numerous folds on the surface of the cerebellum. The *dura mater* passes into the great longitudinal fissure (the membranous fold dipping into it being, as before said, known as the falx), and between the cerebrum and cerebellum (the structure known as the tentorium), but it does not descend into the minor depressions of the brain surface.

Fig. 126.—Upper Surface of Brain, showing the deep Longitudinal Fissure dividing the two Hemispheres and the Cerebellum behind them.

c. Crucial sulcus.
s. Superior external gyrus.
m. Middle external gyrus.
i. Inferior external gyrus.
v. Vermiform process of cerebellum.
ol. Olfactory lobe.

If the two cerebral hemispheres be pushed apart, a large transverse white band of fibres, called the *corpus callosum*, will come into view, which band connects the two hemispheres for rather more than the middle third of their antero-posterior extent (Fig. 129, *cc*).

If the hinder ends of the cerebral hemispheres be forcibly divaricated, then the layer of brain substance, before spoken of as extending forwards from the front of the cerebellum, will come into view. Upon its surface, immediately in front of the cerebellum, two pairs

of rounded prominences may be remarked. These are known as the *corpora quadrigemina*, and the hinder pair, called the *testes*, are rather larger than the anterior pair, which are called the *nates* (Fig. 127, *ns*). The corpora quadrigemina are solid, and do not contain any internal cavity. In front of the midst of the anterior pair, is a solitary prominence named the *pineal gland*.

Just in front of and external to the corpora quadrigemina, there is on each side a small prominence called the *corpus geniculatum*. It is sometimes called the *internal* corpus geniculatum, because, in man, there is a second, contiguous, but more externally placed prominence, named the external corpus geniculatum—a structure which in the cat is hardly to be distinguished.

Fig. 127. — Upper Surface of Brain of Cat — the Cerebral Hemispheres being widely divaricated, to show the parts they naturally cover.

ns. Nates.
pn. Pineal gland.
ts. Testes.
Sv. Superior vermis of cerebellum.
Cc. Corpus callosum.
5. Fifth ventricle.
Cs. Corpus striatum.
Cg. Corpus geniculatum.
Th. The optic thalamus.

The *cerebellum* is attached to the rest of the brain by three pairs of processes or crura. The first of these are included in the fold of brain substance just described. For this fold is exceedingly thin at the middle of its hinder part —called the *valve of Vieussens*—so that the two thicker portions which laterally border the thin part, are reckoned as a pair of crura and spoken of as the *processus a cerebello ad testes*, on account of the parts they connect. The second pair of crura of the cerebellum are the two lateral continuations up into it of the two sides of the pons Varolii, and these are much the largest crura, and form the principal connexions of the cerebellum with the rest of the brain. The third pair of crura are the *inferior peduncles* of the cerebellum or *restiform bodies*, which are the continuations upwards and forwards of the posterior and part of the lateral columns of the spinal cord. They diverge as they advance.

The cerebellum is darker than the cerebrum. Its greatest diameter is transverse, and it consists of two lateral lobes and a median portion, called the vermiform process. The numerous more or less parallel grooves on its surface indicate so many folds of grey substance enclosing white matter within. The central mass of the cerebellum is composed of white matter, and lamellar processes of the same substance proceed in all directions from that central mass into the darker enveloping layer. The cerebellum lies in that fossa of the cranial cavity which we have seen to be bounded in front by the petrous parts of the temporal bones, and behind by the line of attachment of the tentorium to the occipital and parietal bones.

The *medulla oblongata* lies upon the basi-occipital. Its anterior inferior surface is marked by a median groove, on each side of

which is an antero-posteriorly extending portion of white substance (going to the Pons), called the *anterior pyramid*. Outside each such pyramid is a small, more or less hidden, oval structure, termed the *olivary body*, and external to and behind each of these is the band of nervous tissue already spoken of as the restiform body. The middle part of the posterior surface of the medulla is occupied by the posterior *pyramids*, which are placed one on each side of its posterior median fissure, and which are continuous behind with the median dorsal parts of the spinal cord, and in front seem to blend with the restiform bodies.

In order to see the inferior, or ventral, surface of the brain, it must be removed from the cranial cavity, the cerebro-spinal axis being cut through at the foramen magnum, *i.e.*, at the hinder end of the medulla oblongata. This being done, the cut surface of the medulla will exhibit a doubly crescentic arrangement of internally placed grey tissue, similar to that shown by the cut surface of the spinal cord. If, however, sections of the medulla be made at points further and further forwards, it will be seen that the grey matter gradually becomes concentrated (as the medulla advances forwards) near the middle of its dorsal surface.

The ventral surface of the brain being in view, the two lateral parts of the cerebellum are visible, one on each side of the medulla—a small process of each half—called the *floculus*—is connected by the dura mater with that depression on the inner surface of the petrous portion of the temporal bone, which was described as the cerebellar fossa.* Continuing on we find on each side of the anterior end of the anterior pyramids a conspicuous band of transverse fibres, each of which is called a *corpus trapezoideum*. Immediately in front of these bands, is the transverse, convex eminence of the pons Varolii, against the hinder margin of which the front ends of the anterior pyramids abut. The corpora trapezoidea form a transverse band which is interrupted by these pyramids, while the greater band of the pons Varolii is uninterrupted by them. The pons lies upon the anterior part of the basi-occipital bone, and is medianly grooved by an antero-posterior shallow depression, along which runs the basilar artery.

Emerging from the front of the *pons* are two masses of white substances marked with longitudinal striæ, and made up of longitudinal fibres (the *crura cerebri*) which diverge as they advance, and are crossed superficially by two anteriorly converging round cords, the *optic tracts* (which unite to form the optic nerves), and thus a lozenge-shaped space is enclosed. At their opposite extremities the optic tracts run upwards and backwards to the corpora geniculata already noticed. In the hinder part of this space (called inter-peduncular) is a small rounded mass, the *corpus albicans*, which shows an indication of a median division into two lateral halves termed *corpora mammillaria*. In front of this is a slight prominence termed the *tuber cinereum*, from the middle of which projects a hollow

* See *ante*, p. 66.

conical process, the *infundibulum*. At the end of the infundibulum is a small oval reddish mass called the *pituitary body*, which is received into the pituitary fossa (or sella turcica) of the sphenoid bone.

Fig. 128.—Base of the Brain.

F. Frontal lobe.
T. Temporal lobe.
ol. Olfactory lobe.
m. Medulla oblongata.
cb. Cerebellum.
p. Pituitary body.
pv. Pons Varolii.
cc. Crura cerebri.
s. Sylvian fissure.
mm. Corpora mammillaria or corpus albicans.
lp. Locus perforatus anterior.
ct. Corpus trapezoideum.
pa. Anterior pyramid.
I. Source of olfactory nerves.
II. Optic nerve.
III, IV, VI. 3rd, 4th, and 6th nerves (those of eye-muscles).
V. Trigeminal nerve.
VII. Facial nerve.
VIII. Auditory nerve.
IX. Glosso-pharyngeal.
X. Pneumogastric.
XI. Spinal accessory.
XII. Hypo-glossal.

Between the diverging crura and the corpus albicans, is a depressed surface of greyish matter perforated by numerous small vascular openings, whence it is termed the *locus perforatus posterior*.

The tuber cinereum is a lamina of grey nervous matter extending forwards from the corpus albicans to the median junction of the optic tracts, or *optic commissure*.

The pituitary body is very vascular, and in structure is like a ductless gland, consisting as it does of connective tissue with granular matter and nucleated cells.

Another grey space with vascular openings—called the *locus perforatus anterior* — is placed on each side just in front of each optic tract.

Anterior to and beside these small median parts are those voluminous masses the cerebral hemispheres, which thus form a very large part of even the under surface of the brain.

The great longitudinal fissure is seen in the middle line in front, and another but small (Fig. 125) lateral fissure (called the *Sylvian fissure*) separates the anterior (or *frontal*) lobe from the one behind (or *temporal* lobe) of the same hemisphere. The temporal lobes form two great prominences on each side of the brain's under surface. Each is bounded behind by the cerebellum, and is well marked off in front by the Sylvian fissure.

In a groove on the under surface of each frontal lobe is a body, shaped something like a life-preserver, with an oblong head and a thick stalk. This is the *olfactory* lobe or *bulb*. It is made up largely of grey matter, but also contains white fibres. The stalks

connecting the lobes with the under surface of the cerebrum are the crura, or peduncles of the olfactory lobes.

Upon turning back the optic tracts—at their union in the *optic commissure*—a delicate layer is seen to connect them with the anterior end of the corpus callosum. This delicate layer is called the *lamina cinerea*, or *lamina terminalis*. It is also continuous, below the optic commissure, with the tuber cinereum, and it is connected on each side with the *locus perforatus anterior*.

As has been said, the minute cavity of the spinal cord expands within the brain into a series of chambers, filled with fluid, termed "ventricles."

The hindmost or *fourth ventricle* is placed between the cerebellum and the medulla oblongata. It is a flattened, somewhat rhomboidal space, bounded on each side by the crura of the cerebellum. Its floor is formed by the posterior (dorsal) surface of the medulla. Its roof is formed by the cerebellum and by the very delicate layer of nervous matter placed between the processus a cerebello ad testes, and already spoken of as the valve of Vieussens. It is also bounded by a still more delicate film of nervous substance which extends backwards from the cerebellum between its posterior (or inferior) crura, the restiform tracts.

This ventricle is prolonged onwards by a narrow passage into a larger cavity, the third *ventricle*, from the anterior wall of which a small aperture leads right and left into two *lateral ventricles* (one on each hemisphere,) each of which is still further continued on into the olfactory lobe in front of it. The further relations of the various parts will be best understood by studying a median, vertical antero-posterior section of the brain.

If the brain be thus BISECTED in the line of the longitudinal fissure, we find as follows:—

The inner surface of the cerebral hemisphere in view is convoluted, and the cerebrum may be seen to extend forwards together with and above the olfactory lobe in front, and beyond the anterior end of the cerebellum behind

Beneath the middle of the cerebrum we come to the cut surface of the corpus callosum, the front part of which bends rather sharply backwards and downwards, forming what is called the knee (*genu*). Beneath the bent-back extremity of the corpus callosum is the cut edge of the lamina cinerea (or terminalis). At the upper part of this lamina we find the cut surface of a transversely-extending white cord, called the *anterior commissure*, and immediately behind the lamina we find another cord, part of what is called the *fornix*. This latter structure extends, not transversely, but at first upwards and forwards; afterwards curving backwards it passes to the hinder part of the corpus callosum. The fornix is the median part of what is really and morphologically the back of the cerebral hemispheres, each half of the fornix belonging to one of the hemispheres. The layer joining the two diverging and posterior portions of the fornix is called the *lyra*, and together these parts form part of the

outer wall or bag of the cerebrum enclosing the lateral ventricles. Filling up the interval between the corpus callosum and fornix is a double membrane called the *septum lucidum*, a space called the *fifth ventricle* being included between its two layers.

Below the fornix we have evidently cut into a cavity extending down into the infundibulum and bounded in front by the lamina terminalis. This cavity is called the *third ventricle*. A small aperture (the *foramen of Monro*) opens immediately behind the

Fig. 129.—THE BRAIN, AS SEEN WHEN A VERTICAL LONGITUDINAL SECTION HAS BEEN MADE THROUGH ITS MIDDLE.

ac. Anterior commissure.
av. Arbor vitæ of cerebellum.
c. Crucial sulcus.
cm. Corpus albicans.
cc. Corpus callosum.
cq. Corpora quadrigemina.
F. Frontal lobe of cerebrum.
f. Fornix.
fm. Foramen of Monro (between the fornix and the corpus callosum is the fifth ventricle, enclosed by the two vertical layers of the septum lucidum, which pass from the fornix to the corpus callosum).
h. Hippocampal gyrus.
m. Medulla oblongata.
ol. Olfactory lobe.
pv. Pons Varolii.
p. Pineal gland.
pt. Pituitary body.
s. Superior external gyrus.
v. Velum interpositum (between it and the fornix is a space enclosed by the folding over of the cerebrum upon the roof of the third ventricle).
3. Third ventricle.
4. Anterior end of fourth ventricle.
II. Optic nerve, which leads back to the fourth ventricle beneath the cerebellum.
The large white spot above Fig. 3 is the middle, or soft commissure, cut across. The white spot beneath and in front of Fig. 3 is the cut surface of the optic chiasma.

anterior part of the fornix, and a little behind this aperture is the cut edge of a bundle of transverse fibres which form what is called the *soft* (or *middle*) *commissure*. The third ventricle is bounded above by a delicate membrane, the *velum interpositum*, which consists only of the ependyma, the pia mater, and the arachnoid. Its margins are very vascular, and bear the name of the *choroid plexuses*. The vascularity is continued on in that part of the ependyma which passes through the foramen of Monro into the lateral ventricles, but of course the pia mater and arachnoid do not pass through that foramen, as they never get inside the ventricles at all, but are reflected back on the under surface of the fornix. Thus the "choroid plexuses" of the lateral ventricles are (like those of the third) merely portions of the ependyma, which happen to be very vascular, and are not really intrusions from without. This velum interpositum thickens behind and forms a small prominence which projects backwards as the *pineal gland*—reminding us of the pituitary body below. It is reddish and very vascular, and contains two or

more cavities filled with a viscid fluid and gritty matter formed of earthy salts. The third ventricle is bounded inferiorly by the corpus albicans and crura cerebri and by the infundibulum, into which it extends.

The space between the upper surface of the velum and the under surface of the closely applied lyra is morphologically the *outside* of the brain, though, in fact, it is in the middle of the complex whole of the adult structure.

The cavity just described, the third ventricle, continues on backwards as a very narrow passage (the *iter a tertio ad quartum ventriculum*), bounded below by the crura cerebri and above by a layer of nervous matter continuous with the pineal gland, and exhibiting the cut surface of a small transverse cord (the *posterior commissure*), and also two prominences in section—parts of the *corpora quadrigemina*. A little further back, this passage expands into the *fourth ventricle* bounded in the way as already described.

The cerebellum in section shows (as might be expected from what has been said about its structure) radiating, tree-like ramifications of nervous substance (grey and white) known as the *arbor vitæ*.

Other sections are necessary to make clear other matters. Thus, the *foramen of Monro* is the entrance to a cavity which is placed in the cerebral hemisphere of the same side, these two cavities constituting the first and second (or two *lateral*) ventricles.

The so-called foramen of Monro is, in fact, a Y-shaped passage. It is single below, where it communicates with the third ventricle, but divides above into two branches, one to each lateral ventricle.

Each lateral ventricle is said to have two cornua. The *anterior cornu* passes into the frontal lobe and penetrates the olfactory lobe also. The *posterior* or *descending cornu* passes into the temporal lobe. Certain sulci on the surface of the cerebrum extend so deeply as to produce eminences on the inner surface of the lateral ventricles. One such structure in the descending cornu has been termed the *hippocampus major*, and is a very marked elongated and rounded prominence.

Each central hemisphere is, in fact, a bag, with walls of very unequal thickness. Thus, part of the inner wall running along the descending cornu of the lateral ventricle is reduced to the ependyma (with the pia mater and arachnoid), and readily tears (forming what is called the fissure of Bichat), and this rupture having (in man) been mistaken for a natural opening, each lateral ventricle has been supposed to communicate with the exterior close to the crus cerebri.

The hindmost part of the roof of the fourth ventricle is formed of the ependyma alone, the pia mater and arachnoid being reflected over the postero-inferior surface of the cerebellum.

Careful inspection shows that the septum lucidum is really (as already mentioned) double, enclosing a very narrow space—the *fifth ventricle*—the laminæ of the septum lucidum passing downwards from the corpus callosum to the fornix. This fifth ventricle has no connexion with the other ventricles, and it differs from them, not

only in its isolation, but in its nature. It is in no way a prolongation forwards of the spinal canalis centralis.

This fornix is made up of two white cords closely approximated anteriorly and diverging widely behind. Each springs from the corpus albicans, and the two cords (called pillars or crura) ascend (side by side) behind the anterior commissure, and with a branch of the foramen of Monro on the outer side of each. They then curve backwards, diverging, but at the same time united by that delicate membrane called the *lyra*. They become connected with the corpus callosum, and then pass into each descending cornu of the lateral ventricles.

Two rounded bodies (the *optic thalami*) are placed one on each side of the first described cavity (the *third ventricle*), and are connected by the soft (or middle) and posterior commissures. Two other rounded bodies (the *corpora striata*) are placed one in each cerebral hemisphere between the anterior and descending cornua. They are connected by the anterior commissure, which (like the posterior commissure) is formed of white, transverse fibres, while the soft commissure is almost entirely composed of grey matter.

Each corpus striatum is an outgrowth from the middle of the base of its hemisphere, and is the morphological axis of the whole hemisphere.

The optic thalami are thickenings in the outer wall of the third ventricle.

The two cords which have been spoken of as the optic tracts, arise, one on each side, from the optic thalami and run forwards obliquely across the under surface of the brain to join together immediately in front of the infundibulum.

We have seen that the two sides of the brain are connected by the fibres of the corpus callosum and of the three smaller commissures. There is not only this direct transverse connection. Oblique extensions of fibres also connect the right hemisphere with the left side of the spinal cord (and therefore with the left side of the body), and the left hemisphere with the right half of the spinal cord (and therefore with the right side of the body). The fibres which pass forwards through the "anterior pyramids" decussate and then extend through the crura cerebri to the cerebrum. The fibres of the crura radiate within the cerebrum in a fan-like manner, the corpus striatum and thalamus being respectively anterior and posterior to such radiation.

The transverse relation which thus exists between the two sides of the brain and the body (which it supplies with nerves) extends also to the organs of sight, but not to that of smell.

We may now, in conclusion, review the conditions presented by the cerebral convolutions, *i.e.*, by the gyri and sulci of the cerebrum. These are thus disposed as follows:—

On the upper surface of the brain three more or less parallel prominences or gyri, extend antero-posteriorly on each side of the median longitudinal fissure. The innermost of these, the *superior*

lateral gyrus (Figs. 125 and 126, *s*) runs straight from behind forwards till it comes to a transverse furrow, the *crucial sulcus* (*c*), round which it bends, running inwards again, and finally turns outwards and downwards round another sulcus called the *supra-orbital* (*o*). The next gyrus is the *middle lateral* (*m*), which curves outwards and downwards at each end. Finally comes the *inferior lateral gyrus* (*i*), which is seen, in this view, to be somewhat divided towards each end by the terminations of two ascending sulci.

When the brain is vertically bisected, we see, above, the superior lateral gyrus traversed by a feebly indicated antero-posterior groove, while a deep sulcus, the *calloso-marginal sulcus*, divides it incompletely from the *hippocampal gyrus* (Fig. 129, *h*), which immediately adjoins the corpus callosum, behind which it dips down, and passing round the crus cerebri of that side runs forwards the marked prominence of the temporal lobe (Fig. 128, *h*). The sulcus on the concave side of the lower part of this gyrus forms (by projecting into the descending cornu of the lateral hemisphere) the *hippocampus major*, which circumstance gives its name to this gyrus. At the anterior end we see the crucial sulcus (Fig. 129, *c*), with the internal surface of the superior lateral gyrus beneath it.

When the brain is seen in profile, we see at its anterior end the sharp bend upwards and downwards of the superior lateral gyrus around the supra-orbital sulcus (Fig. 125, *o*) and then its ascent behind the crucial sulcus (*c*); after which it runs back along the summit of the hemisphere. Within this is the median lateral fold (*m*), while the whole space embraced by it is occupied by the inferior lateral gyrus traversed by two ascending sulci, the summits of which sulci appear at the side of the upper view of the brain. Next to be noted is the small but very important *Sylvian fissure* (*s*), which forms as it were the axis round which all these convolutions are disposed. Finally the anterior end of the hippocampal gyrus (*h*) makes its appearance beneath and in front of the Sylvian fissure.

When the under surface of the brain is in view we see the lower anterior ends of the three lateral gyri, and the large expanded termination of the hippocampal gyrus is the temporal lobe.

§ **8.** Having now reviewed the nervous centres or cerebro-spinal axis, we may proceed to consider the PERIPHERAL PART of the nervous system, *i.e.*, the nerves which are given off by the axial part of that system.

The nerves which go forth from the cerebro-spinal axis to different parts of the body are bilaterally symmetrical, there being (beyond the olfactory nerves) a pair (one right and one left) of each.

The most anteriorly-situated nerves attain their destination after passing through the foramina of the skull, on which account they are denominated *cranial nerves*.

Of these there are twelve, as follows :—

1. Olfactory.
2. Optic.
3. Oculo-motor.

4. Pathetic (or trochlear).
5. Tri-geminal.
6. Abducent ocular.
7. Facial.
8. Auditory.
9. Glosso-pharyngeal.
10. Pneumogastric.
11. Spinal accessory.
12. Hypo-glossal.

Some anatomists reckon but nine cranial nerves; for they coun the eighth as one with the seventh (calling the facial part its *portio dura*, and its auditory part its *portio mollis*), and reckon the glosso-pharyngeal, pneumogastric, and spinal accessory (all taken together), as their eighth. According to this latter system, the hypoglossal nerve becomes the ninth.

The cranial nerves generally are said to have two kinds of roots or origins, one *deep*, the other *superficial*; but these are but different portions, or stages, of the same nervous cord. The superficial origin of each nerve is the point where it is obviously attached to the surface of the encephalon, while its deep (or *real*) origin indicates the furthest point to which it has yet been traced backwards. A nerve may be visibly attached to the encephalon by one or several roots. Some of these nerves are what is called "sensory," and others "motor," according as they minister to sensation or to motion.

§ **9**. The FIRST, or OLFACTORY nerves, are the numerous delicate fibres which pass from the under surface of the olfactory lobes, through the holes in the cribriform plate, down to the membrane investing the nasal septum and ethmo-turbinals. What are, however, often spoken of as the "olfactory nerves" are the olfactory bulbs themselves, with the stalks, or peduncles, which connect them with the under surface of the cerebrum.

They are composed of grey matter mixed with white fibres, the grey matter being especially abundant in the bulb. Each so-called nerve has at least two roots:—

1. The *external* root is a broad band of white fibres, extending outwards and backwards along the outer margin of the anterior perforated space to the Sylvian fissure (Fig. 128).
2. The *inner* root consists of a narrow band of white fibres, which extends back along the inner side of the anterior perforated space.

§ **10**. The SECOND, or OPTIC, pair of nerves spring superficially from the union of the *optic tracts*, in what is called the *chiasma* or *optic* commissure (Fig. 128).

Their deep origin may be traced back to the optic thalami, corpora geniculata, and corpora quadrigemina. Fibres arising from these parts converge on each side, and form the optic tract, which runs obliquely across the lower surface of the crus cerebri of the same side, behind the anterior perforated space to the chiasma. Posteriorly, it is more flattened; anteriorly, it is more cylindrical.

Arrived at the chiasma, the outer fibres of each tract continue onwards to the optic nerve of the same side beyond the chiasma, while the inner fibres cross over in the chiasma, and continue on in the optic nerve of the opposite side. Some fibres appear to cross from one optic tract to another, along the posterior part of the chiasma, and others to cross, along its anterior part, from one optic nerve to another.

From the chiasma each optic nerve extends through the optic foramen in front of it—diverging widely from its fellow of the opposite side. Emerging from the optic foramen, it is surrounded by the recti muscles of the eyeball, the hinder part of which it enters a little to the inside of its middle, piercing the two outer coats of the eyeball, and expanding within it (to form the *Retina*), as will be hereafter noticed in describing the eye.

The optic nerve is made up of a number of separate bundles of fibres, enclosed in prolongations of the dura mater. In the middle of these bundles runs a small artery called the arteria centralis retinæ.

§ **11.** The THIRD pair of nerves (*oculo-motor*) arise deeply from a grey nucleus in the floor of the iter a tertio ad quartum ventriculum, close to the origin of the fourth nerve. They issue from the cerebral surface in the interpeduncular space between the crura and cerebri, and immediately in front of the pons Varolii (Fig. 128, *III*).

Each nerve traverses the dura mater and sphenoidal fissure, and, after receiving one or two fine branches from the sympathetic, divides, and goes to supply the superior, inferior, and internal recti muscles of the eyeball, as also its inferior oblique muscle, and that of the elevator of the eyelid.

The FOURTH pair of nerves, called also the TROCHLEAR or (from their function of raising the eyeball) PATHETIC, arise deeply from one grey nucleus in the floor of the iter a tertio ad quartum ventriculum, and from another in the floor of the fourth ventricle—close to the origin of the fifth nerve. They issue from the cerebral surface, one on the outer side of each of the crura cerebri (Fig. 128, *IV*), immediately in front of the pons, but each may be traced back round the crus to a spot below and behind the corpora quadrigemina in the valve of Vieussens. It goes through the sphenoidal fissure to the upper oblique muscle of the orbit.

§ **12.** The FIFTH pair of nerves, called also the TRIGEMINAL, arise by two roots, one large sensory root, and one small root called *motor*, because its branches minister not to sensation, but to muscular contraction.

The large root takes its deep origin from behind the olivary body, if not from the floor of the fourth ventricle, and emerges from the surface of the encephalon at the side of the pons Varolii, near its upper and anterior margin, just where its fibres extend upwards and backwards to form the middle crus of the cerebellum.

The small root also takes its deep origin from the medulla oblongata, and possibly from the floor of the fourth ventricle. It

comes to the surface of the encephalon just above the superficial origin of the larger root, which at first conceals it.

At a short distance from its origin the larger root swells out into

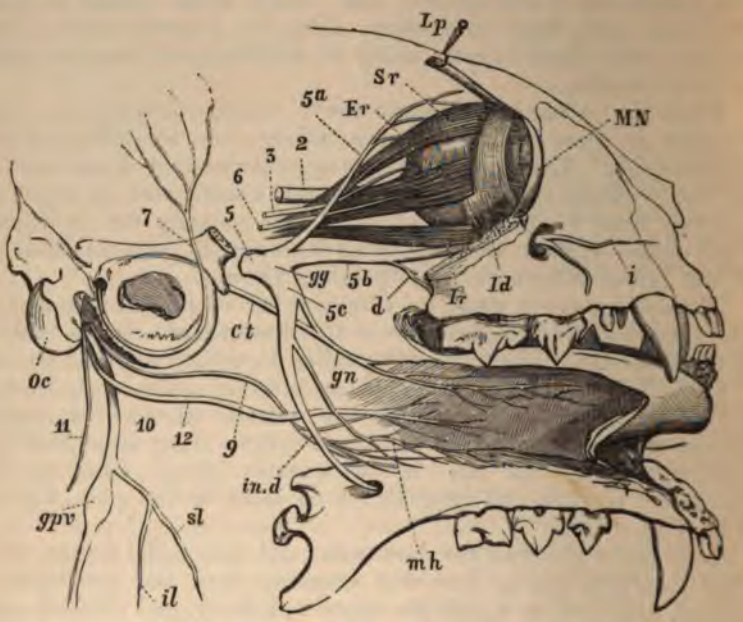


Fig. 130.—Diagram representing the principal Cranial Nerves.

The orbit is cut open, the zygoma and part of the cranial wall removed, and the mandible reflected downwards to show its inner surface.
MN. Third or nictitating eyelid.
Sr. Superior rectus muscle.
Er. External rectus.
Ir. Inferior rectus.
Lp. Levator palpebræ muscle, cut and pulled upwards.
gn. Gustatory nerve, going to tongue.
Ct. Chorda-tympani.
in.d. Inferior dental.
mh. Mylo-hyoid.
Oc. Occipital condyle.
i. Infra-orbital.
d. Dental nerve.
gg. Gasserian ganglion.
gpv. Ganglion of trunk of pneumogastric.
sl and *il.* Superior and inferior laryngeal nerves.
2. Optic nerve.
3. Third nerve, or *oculo-motor.*
5. Trigeminal.
5*a.* Ophthalmic, or first division of fifth nerve.
5*b.* Its second division.
5*c.* Its third division.
6. Sixth nerve, or *abducens.*
7. Facial.
9. Glosso-pharyngeal.
10. Pneumogastric.
11. Spinal accessory.
12. Hypo-glossal.

what is called the *Gasserian ganglion* (Fig. 130, *gg*). It is joined by some sympathetic nervous filaments, and then gives off three large branches, the hindmost of which is joined by the fifth nerve's lesser root.

The first of these three branches, which is the smallest, and one notably distinct from the others, is called the OPHTHALMIC NERVE (Fig. 130, 5*a*), which passes through the sphenoidal fissure, and supplies, by its subdivisions, the eyeball, mucous membrane of the eyelids, lachrymal gland, and the skin of the nose, forehead, and upper eyelid, dividing into its nasal, frontal, and lachrymal branches.

The second of the three branches of the fifth nerve is called the SUPERIOR MAXILLARY NERVE. It passes through the foramen rotundum, and supplies the lower eyelid, the side of the nose, the upper teeth, and the upper part of the mouth and pharynx. After issuing through the foramen rotundum, the nerve crosses to the infra-orbital canal (Fig. 130, 5*b*), which it traverses, and then divides and goes to the parts adjacent. The *anterior* and *posterior dental* branches supply the teeth.

Connected with this nerve is a structure called the *spheno-palatine ganglion*—or *Meckel's ganglion*—which is placed outside the spheno-palatine foramen.

The THIRD BRANCH of the trigeminal (Fig. 130, 5*c*), which is the largest branch, is termed the INFERIOR MAXILLARY NERVE. It passes through the foramen ovale, and supplies the ear, side of the head, lower lip, gums, teeth, salivary glands, and inside of the mouth.

As has been said, it is this part with which the smaller, or motor, root of the trigeminal alone unites. After such union, which takes place just outside the foramen ovale, it subdivides into two portions. The smaller of these (which conveys a motor influence alone) goes to the masticatory muscles; the larger again subdivides into three nerves.

The first of these, the *auriculo-temporal* nerve, passes backwards, under the external pterygoid muscle, and then upwards between the mandible and the external meatus, underneath the parotid gland. There it divides, and its ramifications extend up in the temporal region.

The second, or *gustatory* nerve (Fig. 130, *gn*), which ministers to taste, descends beneath the pterygoid muscles to the side of the tongue, passing above the deep part of the submaxillary gland and crossing Wharton's duct.

In the early part of its course this nerve is joined by a slender branch from the seventh nerve, called the chorda tympani (Fig. 130, *Ct*).

The third, or *inferior dental* nerve (which is the largest of the divisions of the third branch of the trigeminal), descends outside the gustatory nerve and enters the inferior dental canal and supplies the lower teeth (Fig. 130, *in.d*).

Before entering the canal it gives off the *mylo-hyoid branch* (*mh*), which runs down the inside of the mandible to the mylo-hyoid and digastric muscles.

A branch of the inferior dental foramen escapes outwards at the mental foramen and supplies the adjacent muscles.

§ 13. The SIXTH NERVE (Figs. 128 & 130, 6), called also the ABDUCENS, seems again to take its origin from the floor of the fourth ventricle. It comes to the surface at the hinder margin of the pons Varolii, between that margin and the anterior pyramid and olivary body of the same side of the medulla oblongata.

The nerve passes forwards and enters the orbit through the sphenoidal fissure, and is distributed to the external rectus and the choanoid muscles of the eyeball.

The SEVENTH, or FACIAL nerve (called also the *portio dura*, when reckoned as one with the auditory nerve) has its deep origin in the medulla oblongata between the restiform and olivary bodies, and perhaps from the outer wall of the fourth ventricle.

It comes to the surface from the corpus trapezoideum (Fig. 128, *VII.*) just outside and slightly behind the origin of the sixth nerve. Entering the meatus auditorius internus, it proceeds through the aqueduct of Fallopius, and emerging at the stylo-mastoid foramen (Fig. 130, 7), penetrates the parotid gland, when it divides (behind the mandible) into two branches, the subdivisions of which ramify over the side of the head, face and neck, going to the muscles of the ear, scalp, mouth, nose, and eyelids, and also to the platysma-myoides (Fig. 88, *n*).

Near its exit from the aqueduct it gives off a slender branch called the *chorda tympani*, which enters the hinder part of the tympanic cavity (by a canal opening close to the bony frame of the tympanic membrane), crosses that membrane and that process of the malleus which is called the manubrium,* and finally escapes through the fissura Glaseri to join the gustatory nerve—as already mentioned.

§ **14.** The EIGHTH, or AUDITORY nerve (called also the *portio molle* when reckoned as one with the auditory nerve), has its deep origin in the floor of the fourth ventricle. It also receives accessions by fibres from the restiform body and, perhaps, also from the pons. It emerges from the surface of the encephalon behind the pons, from the corpus trapezoideum (Fig. 128, *VIII.*), just behind and external to the emergence of the seventh nerve. It enters the meatus auditorius internus along with the seventh nerve, and bifurcates at the end of that canal, one part going through the anterior part of the cribriform lamina to the cochlea and the other through its hinder part to the vestibule, as described in treating of the organ of hearing.

§ **15.** The NINTH, or GLOSSO-PHARYNGEAL nerve (Figs. 128, *IX.*, and 130, 9), has its deep origin in the grey matter of the posterior part of the medulla oblongata. It quits the surface of the encephalon just behind (and below) the origin of the seventh nerve, emerging behind the upper part of the olivary body and superficially connected with the restiform body. It quits the skull by the jugular foramen, and then descends between the carotid artery and the jugular vein, but turns forwards and inwards at the lower border of the stylo-pharyngeus muscle, and goes to the tongue, passing under the hyoglossus muscle and being distributed to that organ and to the tonsil and pharynx.

The TENTH, or PNEUMOGASTRIC nerve (Figs. 128, *X.*, and 130, 10), called also the PAR VAGUM, is the longest of all the nerves of the encephalon, extending downwards as far as the stomach. Its deep origin is situated in the grey nuclei of the hinder part of the medulla

* For the explanation of these terms, see the description of the internal ear *infra*, p. 298.

oblongata, nearer the middle line than the origin of the ninth nerve. Superficially it arises from the restiform body, close to and immediately below the ninth nerve, and springs from a considerable number of roots—in a series one below another, forming a flat fasciculus. It passes out of the jugular foramen beside the ninth nerve. It develops two ganglia; one near its root and one (Fig. 130, *gpv*) on its trunk.

It then descends the neck between the internal jugular vein and carotid artery and passes into the thorax above the innominate vein and root of the lung, whence it passes down the œsophagus, in the posterior mediastinum, to the stomach.

Pharyngeal and *laryngeal branches* go to the pharynx and larynx respectively.

Cardiac branches pass down to the heart, both from the cervical and thoracic parts of the nerve.

Pulmonary branches are given off to the lungs, the largest ones being those which pass to those organs on the hinder aspect of the lung root.

The œsophagus also receives branches from the pneumogastric, termed *œsophageal*, on both sides of the lung root.

The nerve ends in its *gastric branches*. The left pneumogastric passes backwards on the ventral aspect of the œsophagus and is distributed over the ventral side of the stomach (some fibres going to the liver) while the right pneumogastric descends on the dorsal aspect of the œsophagus and is distributed over the dorsal side of the stomach—some fibres going to the spleen.

The ELEVENTH, or SPINAL ACCESSORY nerve (Figs. 128, *XI.*, and 130, ^{11}), is a comparatively insignificant one. It takes origin lower down than any other nerve reckoned as belonging to the encephalon, namely, below the foramen magnum, from the side of the myelon, by a series of delicate roots. Ascending into the skull through the great occipital foramen, it passes out again through the jugular foramen, in two divisions. One division is completely united with the pneumogastric—the union commencing at the ganglion of the root of that nerve and being completed below the ganglion of its trunk. The other division turns backwards and supplies the sterno-mastoid and trapezius muscles.

The TWELFTH, or HYPOGLOSSAL nerve (Figs. 128, *XII.*, and 130, ^{12}), is the nerve of the muscles of the larynx and hyoid, including the tongue, to which it conveys motor impulses. Its deep origin is in the grey matter of the posterior part of the medulla oblongata, close to the posterior fissure. Its fibres are said to undergo a partial decussation in the floor of the fourth ventricle. It quits the encephalon by scattered roots which come forth between the anterior pyramid and the olivary body in a line with what we shall find to be the anterior roots of the spinal nerves situated below. The roots collect and pass through the anterior condyloid foramen. Thence the nerve descends to the inferior margin of the digastric and then turns forwards and runs, above the hyoid, to the under part of the tongue.

§ **16.** Here it may be well to present a preliminary SUMMAI the nerves of the encephalon with respect to their functions, alth the functions of the nervous system and of its main divisions wi described more fully later.

The twelve nerves just enumerated may be divided into categories: (A.) Those which minister to special sense; (B.) which are motor, and (C.) those which minister both to con sensation and to motion.

The nerves which minister to special sensation are the second, eighth, the gustatory branch of the fifth, and the to branches of the glosso-pharyngeal.

The third, fourth, sixth, seventh, and twelfth, are motor ne The fifth, glosso-pharyngeal, pneumogastric, and spinal acce nerves are all both motor and sensory, though the glosso-pharyn is mainly sensory.

§ **17.** The SPINAL NERVES arise systematically, in pairs, opposite sides of the spinal marrow. They are related in numb the divisions of the axial skeleton, or vertebræ, and (as has said in describing that skeleton) they pass out of the neural in the intervals between the neural arches. They are seve reckoned as cervical, dorsal, lumbar, sacral, or caudal, accordi their proximity to similarly named vertebræ, each nerve takin name of that vertebra which forms the anterior boundary of its of exit. Thus, inasmuch as one spinal nerve comes out abov front of) the atlas, there are eight cervical nerves, thirteen d seven lumbar, and three sacral, while the rest are caudal.

The spinal nerves each arise by two roots, and each, after le the neural vertebral canal, divides into two conspicuous bra (one dorsal and the other ventral), besides sending a twig to sympathetic.

Of these two series of conspicuous branches it is the ventral which constitutes the nerves of the limbs, while, in the int between the limbs, the ventral branches pass round in the body —the thoracic ones in the intercostal spaces, and the abdominal between the internal oblique and transversalis muscles, as wi shortly described.

The ROOTS by which each spinal nerve arises are (as has said) two in number: one *anterior* (ventral), and the other *pos* (dorsal), and each is made up of a number of small bundles *culi*) of nerve-fibres.

The funiculi of the *posterior* (dorsal) root come forth from posterior lateral furrow. They are larger and more numerous are the funiculi of the anterior root. Within the substance of the the fibres of the posterior—or dorsal—root of each nerve may be t diverging in three directions, namely, postaxially, or away fro brain, preaxially, or towards the brain, and transversely across. first pass along the grey matter to the anterior cornu and an white columns. The second advance through the grey matter t posterior columns. The third (transverse fibres) enter the pos

cornu, and some cross the posterior commissure and reach the posterior and lateral columns of the opposite side.

The funiculi of the *anterior* (ventral) root pass straight to the anterior cornu and there also diverge postaxially, preaxially, and horizontally.

The funiculi of the posterior (dorsal) root unite to form a single cord, which is furnished with an oval mass of grey matter, or ganglion, varying in size with the size of the nerve.

The funiculi of the anterior (ventral) root unite together without developing any ganglion, and the cord so formed unites with that from the posterior root beyond (*i.e.*, distally to) the ganglion.

Each spinal nerve having thus been formed by the union of its roots, divides (as before said) into two conspicuous branches termed its DORSAL and VENTRAL PRIMARY DIVISIONS. Fibres from each of the two roots are so blended in the part where the nerve is single, that after its division each of its two parts contain fibres derived from both the anterior (ventral) and posterior (dorsal) root of the nerve.

The DORSAL PRIMARY DIVISIONS of the spinal nerves are distributed to the muscles and skin of the dorsal region, and divide into *internal* and *external* branches.

The *cervical* internal branches pass upwards in the vicinity of the neural arches. The external branches pass outwards, and supply the cervical prolongations of the erector spinæ.

The *dorsal* internal branches proceed between the multifidus spinæ, and either the semi-spinalis dorsi or the longissimus dorsi—therefore in the vicinity of the neural arches. Their external branches (which become bigger from before backwards) pass beneath the longissimus dorsi to the interval between it and the sacro-lumbalis or its continuation forwards.

The *lumbar* internal branches pass backwards close to the zygapophyses into the multifidus spinæ, therefore close (once more) to the neural arches. Their external branches enter the erector spinæ, which represents the longissimus dorsi and sacro-lumbalis undifferentiated.

The *sacral* external and internal branches are distributed in an analogous manner.

The VENTRAL PRIMARY DIVISIONS of the spinal nerves are distributed to the more ventrally situated parts of the body, and they are generally a good deal larger than are the dorsal primary divisions. They do not divide into an internal and external branch as do the dorsal primary divisions of the spinal nerves, but they tend to unite together in sundry *plexuses*, and each gives off a minute branch inwards to the sympathetic system, and thus in a certain sense even these anterior primary divisions bifurcate; they bifurcate, namely, into a large outer division, and a minute inner one going to the sympathetic.

The ventral primary divisions of the *cervical nerves* pass outwards between the scaleni and the rectus anticus major muscles.

The first four or five form an interlacement called the *cervical*

plexus, placed opposite the first four vertebræ below the sterno-mastoid muscle, and connected, near the skull, with the pneumo-gastric, hypoglossal, and sympathetic nerves.

The fifth and sixth cervical nerves give off a branch called the *phrenic* nerve, which passes backwards between the pleura and the pericardium, and is distributed to the diaphragm.

§ **18.** The three posterior cervical nerves unite to form an interlacement called the BRACHIAL PLEXUS, which is of much greater size than the cervical plexus, and gives origin to the nerves of the FORE-LIMB. It is reinforced by the first dorsal nerve, and the plexus extends down from the lower part of the neck to the axillary space.

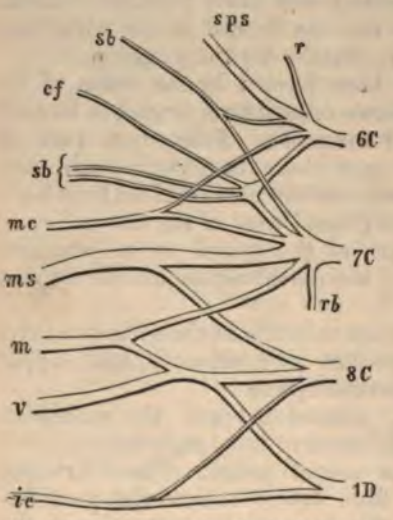


Fig. 131.—DIAGRAM OF THE RIGHT BRACHIAL PLEXUS.

6C, *7C*, and *8C*. Sixth, seventh, and eighth cervical nerves.
1D. First dorsal nerve.
cf. Circumflex nerve.
ic. Internal cutaneous nerve.
m. Median nerve.
mc. Musculo-cutaneous nerve.
ms. Musculo-spiral nerve.
r. Nerve to rhomboideus muscle.
rb. Respiratory nerve of Bell.
sb. Subscapular nerves.
sps. Supra-scapular nerve.
v. Ulnar nerve.

The connexions formed by the nerves in the plexus are somewhat apt to vary, but the following conditions appear to be normal. A large branch from the eighth cervical nerve unites with the main branch of the first dorsal to form a trunk which (after giving off a small branch to help to form the median) continues on as the *ulnar* nerve (Fig. 131, *v*). Delicate branches from the first dorsal and eighth cervical also unite to form the *internal cutaneous nerve* (*ic*). The *median* nerve is formed by the junction of the small offshoot from the ulnar (already mentioned), with a branch from the seventh cervical nerve. The largest branch of the seventh, however, unites with a considerable branch from the eighth cervical to form the *musculo-spiral* nerve. From close to the root of the seventh cervical the *external respiratory nerve of Bell* passes backwards. The *musculo-cutaneous* nerve is formed by the junction of slender branches from the sixth and seventh cervical nerves, and from the junction of two stouter branches from the same two nerves there arise the *circumflex* and the *subscapular* nerves. Another subscapular nerve is formed by the junction of very slender branches from the sixth and seventh cervical nerves, while from the sixth there springs a very considerable *supra-scapular* nerve, and a small branch which goes to the rhomboideus muscle.

The *internal cutaneous* nerve, as its name implies, passes to the

skin of the inner side of the arm. It pierces the fascia and becomes cutaneous at about the middle of the inner side of the upper arm, and is distributed to both the anterior and posterior surfaces of the limb below the elbow.

The *external respiratory nerve of Bell*, or *posterior thoracic* nerve, at first traverses the scalenus muscle and then passes backwards within (*i.e.*, nearer the ribs than) the rest of the brachial plexus to the side of the thorax, where it lies upon the serratus muscle, which it supplies.

The *supra-scapular* nerve passes between the trapezius muscle to the dorsal surface of the scapula, and supplies the supra and infra-spinatus muscles.

The *subscapular* nerves pass to the inner side of the blade-bone, and supply the subscapularis, teres major, and latissimus dorsi muscles.

The *musculo-cutaneous* nerve descends obliquely through the biceps and brachialis anticus muscles to the outer side of the fore-limb. It supplies the muscles named as well as the coraco-brachialis, and then proceeds to the skin of the outer side of the limb below the elbow.

The ULNAR nerve passes down on the inner side of the brachial artery to the middle of the upper arm, and then turns backwards to between the olecranon and inner condyle, where it is subcutaneous. It then descends the lower arm (side by side with the ulnar artery), supplying, in its course, the flexor profundus digitorum and the flexor carpi ulnaris muscles. Arrived at about the lower third of the ulnar artery, it bifurcates into a dorsal and a palmar branch. The dorsal branch divides at the carpus into two branchlets, one of which runs along the outside of the fifth digit, and the other (after receiving a branch from the radial) subdivides and runs along the inner side of the fifth, and the outer side of the fourth, digits. The palmar branch passes within the pisiforme, and divides into branchlets, which go to the muscles of the pollex and fifth digit and to the interossei; another passes along the outside of the fifth digit on its palmar aspect; another similarly supplies the contiguous sides of the fourth and fifth digits, and sends a twig to the median nerve.

The MEDIAN nerve descends and passes through the internal condyloid foramen of the humerus. It then dips below the pronator teres, and proceeds amidst the flexor muscles to the wrist; when beneath the annular ligament it divides into three branches. On its way it supplies the pronators, the radial carpal flexors, and the long flexors of the digits where not supplied by the ulnar nerve. Of its three branches, the most internal goes to the pollex and the adjacent palmar border of the index digit. The middle branch descends into the second interosseous space, and supplies the contiguous sides of the index and middle digits. The third branch similarly supplies the adjacent sides of the third and fourth digits on their palmar aspect.

The CIRCUMFLEX (or *axillary*) nerve passes backwards at the

lower margin of the subscapular muscle (with the posterior circumflex artery) between the scapula and teres major, and goes to the deltoid, teres minor, and skin of the shoulder.

The MUSCULO-SPIRAL nerve is that supplying the supinator and

Fig. 132.—NERVES OF RIGHT FORE-PAW—PALMAR ASPECT.

m. Median nerve supplying pollex, index, medius, and part of annulus, digits.
u. Ulnar nerve supplying the minimus and the other part of the annulus, digits.

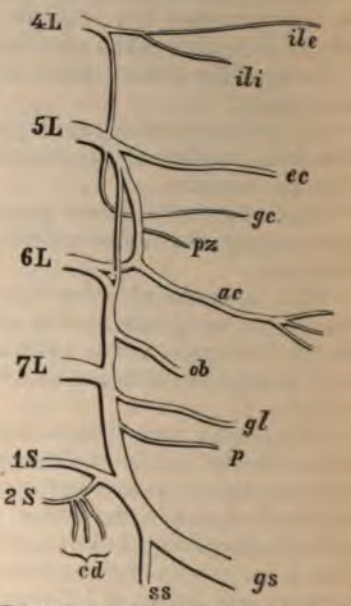


Fig. 133.—DIAGRAM OF THE LEFT LUMBAR AND SACRAL PLEXUSES.

4L, *5L*, *6L* and *7L*. Fourth, fifth, sixth, and seventh lumbar nerves.
1S and *2S*. The sacral nerves.
ec. Anterior crural nerves.
cd. Caudal nerves.
ec. External cutaneous nerve.
gc. Genito-crural nerve.
gl. Gluteal nerve.
gs. Great sciatic nerve.
ile. Ilio-hypogastric nerve.
ili. Ilio-inguinal nerve.
p. Pudic nerve.
ps. Nerve to psoas muscle.
ss. Small sciatic nerve.

extensor muscles, as well as the skin of the back of the lower part of the upper arm, and that of the back of the fore-arm and paw. It takes origin above the vessels of the axilla, and passes round the back of the humerus to the radial side of the front of the fore-arm, when it descends between the supinator longus and the insertion of the brachialis anticus, and then divides into the *radial* and *posterior inter-osseous* nerves.

The former of these (radial) passes down the fore-arm outside the radial artery, and hidden by the supinator longus, till near the wrist, where it becomes subcutaneous, and is distributed to the dorsum of the pollex, index, and median digits. One branch goes to the pollex

and adjacent dorsal border of the index, and another branch supplies the adjacent sides of the index and third digits, and the radial side of the fourth digit, also giving off a branchlet to join the dorsal branch of the ulnar nerve.

The posterior interosseous nerve passes through the supinator brevis to the back of the fore-arm, where it divides, and is distributed to the muscles of that region.

The ventral primary divisions of the DORSAL, or THORACIC NERVES, pass out in the intercostal spaces along with the intercostal blood-vessels, the last passing along behind the last rib. They soon dip between the internal and external intercostal muscles, and each gives off a twig to the skin at a point about midway between the vertebral column and the sternum. The more posterior of the thoracic nerves enter the abdominal wall, and go to the margin of the rectus, passing, on their way, between the internal oblique and the transversalis. They enter the rectus and send small branches to the skin. The last dorsal nerve sends back a branch which unites with the first lumbar, and so joins in what is called the lumbar plexus. Each thoracic spinal nerve sends a short twig, inwards and downwards, to join the sympathetic.

§ 19. The ventral primary divisions of the LUMBAR NERVES are larger than those of the dorsal nerves. They severally give off a filament to the sympathetic, and then unite in loops to form a continuous, complex interlacement of branches, called the LUMBAR and SACRAL PLEXUSES, whence come the nerves of the HIND-LIMB. The lumbar plexus lies on the ventral aspect of the lumbar transverse processes, and is formed by the fourth, fifth, sixth, and seventh lumbar nerves. The fourth lumbar nerve, after giving off a branch which divides into the *ilio-hypogastric* and *ilio-inguinal* nerves (Fig. 133, *ile* and *ili*), sends a branch backwards, which joins the root of the fifth lumbar nerve. From this junction the long *genito-crural* nerve (*gc*) is given off, and shortly afterwards that called the *external cutaneous*. The trunk then bifurcates, its two branches joining the two branches into which the sixth lumbar nerve divides. The larger pair of branches thus joining, give origin to the *anterior crural* nerve (*ac*), while a small twig to the psoas muscle is given off by that root of the anterior crural which is contributed by the fifth lumbar nerve. The other two branches from the fifth and sixth nerves unite to form a branch which gives off the *obturator* nerve (*ob*), and then passes backwards to join the seventh lumbar nerve, the thick trunk resulting from their junction being called the *lumbo-sacral cord*, and constituting the main root of the great sciatic nerve.

It is called "lumbo-sacral" because the nerves which come out of the anterior sacral foramina are reckoned as forming by themselves a *sacral plexus*, which plexus is placed in communication with the lumbar plexus by means of this "lumbo-sacral cord."

From the outer side of this "cord" the *pudic* and *gluteal* nerves are given forth. The two sacral nerves unite together—after the second sacral has given off some branches to the tail (*cd*)—to form

a small trunk, which unites with the large lumbo-sacral cord, and forms the *great sciatic* nerve, the *lesser sciatic* nerve being given off close to the junction of the "small trunk" just mentioned, with the lumbo-sacral cord (*ss*).

The sacral plexus lies on the ventral surface of the pyriformis muscle.

The *ilio-hypogastric* nerve comes forth from the anterior part of the psoas, pierces the transversalis, and divides—branches coming to the surface in the skin of the hinder part of the abdomen. The *ilio-inguinal* nerve follows a very similar course to the last, but is distributed to the skin of the groin and external generative organs.

The *genito-crural* nerve, which is a very long one, passes back beneath Poupart's ligament, one part goes to the skin of the thigh and the other part to the spermatic cord in the male, and to the vicinity of the vaginal orifice in the female. The *external cutaneous* nerve also passes back beneath Poupart's ligament and goes to the skin outside the hip and thigh.

The *obturator* nerve, which is of large size, passes along the side of the pelvis, with the obturator vessels, and perforates the obturator membrane, being distributed to the external obturator muscle, the pectineus gracilis, and the adductor. The ANTERIOR CRURAL nerve is the great nerve of the front of the thigh, and is the largest of those which quit the lumbar plexus. Coming out from the psoas it passes down and divides, giving off nerves to the skin of the front and inside of the thigh, to the skin of the inner side of the leg and foot, and also branches to the sartorius, pectineus, and quadriceps extensor muscles. The *superior gluteal* nerve passes out in front of the pyriformis, and is distributed to the gluteal muscles.

The GREAT SCIATIC nerve, which is the largest nerve in the body, passes out through the sacro-sciatic notch behind the pyriformis muscle, and proceeds between the great trochanter and the tuberosity of the ischium, beneath the gluteus maximus, and (with the sciatic artery) resting upon the obturator internus and quadratus femoris muscles. It descends beside the adductor magnus to the popliteal space, bifurcating into two branches, called respectively the *internal* and *external popliteal* nerves. The first of these (which is the larger) continues down behind the popliteus muscle, and then takes the name of *posterior tibial* nerve, descending near the posterior tibial artery to the inner malleolus, and dividing into the *internal* and *external plantar* nerves. The former of these accompanies the internal plantar artery, and is distributed to the three inner (or tibial) toes, and to the inner side of the fourth. The external plantar nerve goes to the fifth toe and outer side of the fourth, after crossing obliquely beneath the sole with the external plantar artery. The posterior tibial nerve supplies all the flexor muscles of the foot and toes, and the skin of the sole of the foot and part of the back of the leg. The second division of the popliteal nerve, *i.e.*, the *external popliteal*, or *peroneal* nerve, curves

round the head of the fibula beneath the peroneus longus and divides into two branches. The first of these, called the *musculo-cutaneous* nerve, descends between the extensor longus digitorum and the peronei muscles to the dorsum of the foot, where it ramifies. It supplies the peronei and skin of the front of the leg and dorsum of the foot. The second division of the external popliteal nerve is called the *anterior tibial*. It passes obliquely inwards beneath the extensor longus digitorum, and descends with the anterior tibial vessels to the ankle, where it divides, one part continuing on to the first interosseous space, the other passing outwards obliquely beneath the extensor brevis. It supplies the tibialis anticus and the extensors both long and short, as well as the skin of part of the dorsum of the foot.

Of the smaller branches from the sacral plexus, the *pudic nerve* is that which supplies the generative organs and adjacent parts. The other nerve, the origin of which has been mentioned, is the *small sciatic* nerve, which arises behind the pyriformis, descends beneath the gluteus maximus, and gives branches to that muscle and to the skin of the lower part of the buttock and back of the thigh.

§ **20.** The NERVES OF THE TAIL come from the sacral plexus, which gives origin to a lateral nerve which runs along each side of the tail, giving off branches to the muscles. The more anterior part of the tail is also supplied by branches of the cauda equina, which are continued into it.

§ **21.** The SYMPATHETIC SYSTEM consists of an immense number of small nerves (of pale fibres), with many ganglia scattered through the body, and specially connected with the viscera and blood-vessels, the whole system being connected with the spinal system of nerves by two elongated, *gangliated cords*, which extend from before backwards, one on each side of the ventral aspect of the skeletal axis, from the pre-sphenoid to the tail. It is with these two longitudinal cords that the several filaments already noticed as passing from the spinal nerves close to their roots, unite. The sympathetic visceral nerves, in passing to the organs which they supply, traverse those folds of membrane (the mesenteries) which, as we have seen, suspend the viscera from the backbone.

In the trunk, the sympathetic nerves and ganglia are here and there congregated together, forming great *plexuses*, whence other nerves proceed.

In the head, filaments of the sympathetic communicate with all the cranial nerves (except those nerves of special sense, the "optic" and "olfactory" nerves), and where these unions take place, certain *ganglia* are developed.

The CORDS, placed symmetrically one on each side of the ventral aspect of the vertebral column, from the base of the skull to the tail, each developes ganglia, which in the trunk correspond in number with the dorsal and lumbar vertebræ. These cords are connected in front with sympathetic nerves of the skull, while

posteriorly they meet together and terminate in a single elongated ganglion beneath the tail.

The filaments which unite the several ganglia with the several spinal nerves are formed partly of white and partly of grey fibres, and the same is the case with the horizontal cords which connect together, on each side, the series of ganglia. The white fibres are deemed to come from the spinal system.

In the neck, the sympathetic is intimately connected with the pneumogastric.

The great PLEXUSES of the sympathetic are three in number: one in the thorax, called the *cardiac* plexus; one in the abdomen, called the *solar* plexus; and one in the pelvis, called the *hypogastric* plexus. Each is a single, median structure, and each furnishes sympathetic nerves to adjacent viscera.

The THORACIC PARTS of the gangliated cords, lie on a line with the heads of the ribs, between the pleura and the intercostal vessels. Occasionally two of the ganglia of each side may coalesce.

The branches given off by the first five or six ganglia go mostly to the aorta and adjacent parts, and are small in size; but those of the more posterior ganglia join together to form on each side the *splanchnic nerve*, which penetrates the diaphragm and goes to a special ganglion, called "*semilunar*," which is situate in the solar plexus.

The LUMBAR PARTS of the gangliated cords approach each other, lying on the ventral aspect of the bodies of the vertebræ, along the inner margin of each psoas muscle. In the SACRAL region the cords are much smaller, and they approach each other yet more, uniting together in a single median ganglion (*ganglion* impar) beneath the tail.

Of those complex entanglements of nerves and ganglia, the great plexuses, the first, or CARDIAC PLEXUS, lies on the base of the heart and on the aorta and pulmonary artery. It receives the cardiac branches of the pneumogastric nerves, with the cardiac branches from the cervical ganglia of the sympathetic. It constitutes the nervous system of the heart.

The SOLAR (or EPIGASTRIC) plexus is the largest of all, and lies in the anterior part of the abdomen, between the stomach, aorta, and pillars of the diaphragm, and between the suprarenal capsules. It receives not only the splanchnic nerves, but also some branches from the pneumogastric. It contains several ganglia, the two largest of which are called *semilunar*. It gives off very many branches, accompanying the arteries to the different abdominal viscera.

The HYPOGASTRIC plexus is that which furnishes sympathetic branches to the pelvis, and lies between the right and left iliac arteries. It receives branches from the lumbar part of the gangliated cords, and from the plexuses in front. Unlike the solar plexus, this one contains no ganglia. It sends backwards two prolongations, one on each side of the pelvic viscera, these prolongations forming what is specially called the pelvic plexus, nerves of which are spread about the pelvic viscera, especially the bladder and generative organs.

The sympathetic system may be regarded either as a separate system or as but a series of internally directed branches of the spinal nerves of each side of the body. According to this latter view, each spinal nerve divides into three branches. One of these branches passes upwards as a dorsal nerve; another follows the body wall—the ventral branch of each spinal nerve—while the third branch (hitherto called the filament to the sympathetic) passes inwards in the line of the mesenteries. These last inner branches or filaments are serially connected by horizontal nerves, *i.e.*, by the two longitudinal gangliated cords.

The sympathetic filaments which ramify around the arteries are termed the *vaso-motor* nerves.

THE ORGANS OF SPECIAL SENSE

§ **22.** Feelings of different kinds will be more fully considered amongst the functions of the nervous system, but their existence must be recognized in treating of the organs which minister to them, and these have now to be considered.

The special ORGAN OF TOUCH is the skin, above all the skin of the muzzle, tongue and digits. The nerves of the vibrissæ and the touch corpuscles are the agents which induce this sensation.

The structure of the skin, with its papillæ, the touch corpuscles and Pacinian bodies have been already described in the second chapter.

The nerves at their ultimate terminations in the skin, divide, and may form small terminal plexuses, or enter touch corpuscles or Pacinian bodies (as earlier described), or terminate in *end bulbs*, which are spheroidal bodies about $\frac{1}{600}$ of an inch in diameter. Each of these consists of a capsule of connective tissue, with nuclei —the capsule containing a core of clear, soft, granular matter.

§ **23.** The ORGAN OF TASTE is, in the main, the tongue, especially its back part, but the under surface of the soft palate also seems to participate in the faculty. The tongue with its three kinds of papillæ, has been already described. It is supplied with three nerves: (1) the gustatory, (2) the lingual branch of the glosso-pharyngeal, and (3) the hypoglossal. The last is motor, but the first two are sensory. The gustatory nerve goes to the mucous membrane and papillæ of the fore-part and sides of the tongue, the lingual branch of the glosso-pharyngeal goes to the mucous membrane at the base and side of the tongue, and especially to the circumvallate papillæ.

The soft palate and also the anterior pillars of the fauces, have short, soft papillæ on their mucous membrane, and these parts are supplied with fibres from the superior maxillary and glosso-pharyngeal nerves.

The parts, however, which by their contact with foreign bodies are the actual ultimate occasions of the sense of taste are certain minute structures called GUSTATORY CELLS, which are enclosed in other structures called GUSTATORY BULBS. These latter are very small

spheroidal capsules situated beneath the epithelial surface, and opening upon that surface by a minute aperture termed the *gustatory pore*. These bulbs lie in sheltered situations, such as *e.g.*, in furrows on the tongue and in the outer (lateral) surfaces of the circumvallate papillæ—the pores opening into the fossa surrounding each such papilla. There are some hundreds of such circumvallate gustatory bulbs, while comparatively few are found upon the fungiform papillæ. Each bulb encloses a number of horny, spindle-shaped bodies, with their apices directed towards its pore. These are called investing cells, and are of epithelial nature; they serve to enclose and protect the actual *gustatory cells*, each of which is a spheroidal mass of protein substance, ending above (distally) in a rod-like filament. These filaments about reach to the aperture of the gustatory pore. At their base or proximal end each gustatory cell gives off a minute filament, which becomes continuous with one of the ultimate ramifications of the nerves of taste.

Thus the ultimate organs of taste appear to be so many minute rods proceeding from cells.

§ **24**. The ORGANS OF SMELL are contained within the cavity of the nostrils, protected by bones and cartilages. The bones have already been described, and extend backwards from the anterior to the posterior nares.

The passage which connects these openings gives entrance to currents of air, which habitually pass in through them in respiration, and exclusively through them when the mouth is closed.

But these currents only pass through the lower part of the nasal cavity, which on that account is called the *respiratory portion* of it. The nasal cavity, however, ascends much above this, namely, up between the orbits, and it is there that the sense of smell is exercised, and into this part the odour-bearing air can only pass by the slow process of diffusion, unless by the action of sniffing, which draws it upwards into that upper part of the nasal cavity.

The *cartilages of the nose* are dependencies of the median cartilage or *cartilage of the septum*, which continues on the more posteriorly situated vertical bony septum (formed by the median ethmoid and vomer), reaching up to the nasal bones and in front of them. Below, it rests (in front of the vomer) on the median raised ridge, formed by the junction of the two maxillæ, on the upper surface of the maxillary part of the bony palate. Above, it expands so as to serve as a continuation of the nasal bones, while lateral prolongations of the median cartilage extend out, one on each side, and are so curved (first outwards, then downwards, and then inwards) that each nearly surrounds (while it keeps open) the lower part of one of the nostrils. Behind, each is attached to the maxilla. On the dorsum of the distal end of the median cartilage (between its lateral expansions) there is a deep median groove.

The *nasal fossæ* are those cavities the bony walls of which have been already described. They extend from the upper surface of the palate below, to the under surface of the cribriform palate above,

and are therefore higher in their middle part than either at the anterior or posterior end—at the anterior and posterior nares. These fossæ communicate with the frontal sinuses, as has already been noted in describing the skull. The outer wall of each nasal fossa exhibits the three prominences formed by the superior and inferior mass of cells of the lateral ethmoid, between which is the *upper meatus* as well as that formed by the maxillo-turbinal, above which is the *middle meatus*, while the *inferior meatus* is below the maxillo-turbinal. These parts are all invested with thick mucous membrane, so that their projection inwards and antero-posteriorly is much more marked in the living or freshly-killed animal than it is in the dry skeleton.

At the roof of the fossa are the openings into the sphenoidal sinuses into which the mucous membrane is prolonged.

In the inferior meatus is the lower termination of the lachrymal canal.

The *mucous membrane* which invests the nasal fossæ is called the *Schneiderian* (or *pituitary*) membrane. It is very vascular, and is inseparably united with the periosteum and perichondrium of the different parts. At the margins of the anterior nostrils it becomes continuous with the external skin, while at the posterior nostrils it becomes continuous with the mucous lining of the pharynx.

The epithelium which coats the mucous membrane varies in character in different places. That portion which lines the lower part and front of the nose is lined with squamous epithelium. In the respiratory part of the cavity (*i.e.*, the maxillo-turbinal bones and all the parts below them) it is columnar and ciliated. In the olfactory part of the cavity (*i.e.*, the two masses of the lateral ethmoid and the upper part of the septum) the epithelium is columnar but not ciliated. The mucous membrane of this special, olfactory part is very thick, soft and pulpy.

The SPECIAL ORGANS OF SMELL are certain peculiar bodies called OLFACTORY CELLS, spindle-shaped, nucleated, and placed between the columnar epithelial cells. Each such spindle-shaped cell sends out towards the surface a rod-like process, provided with long, slender hairlets which project slightly beyond the surface. At its opposite pole the cell sends out a deep process, which appears to be continuous with the ultimate ramifications of the olfactory nerves.

Thus the ultimate organs of smell appear to be so many minute rods proceeding from cells.

The OLFACTORY NERVES come off from the under surface of the flattened end of each olfactory bulb, and piercing the cribriform plate are distributed to the mucous membrane which invests the two lateral masses of the ethmoid and the upper part of the median septum. The nerves ramify in a plexiform manner over these parts, forming a fine net-work. They are entirely composed of pale fibres, and are finely granular.

The rest of the mucous membrane is provided with nerves which are ramifications of the fifth pair of cranial nerves.

Thus the maxillo-turbinals do not minister to smell, but serve, as it were, to strain and also to warm the air at first received within the nostrils, and which is subsequently diffused into the truly olfactory upper chamber.

In connection with the nasal cavity a peculiar structure, called the *organ of Jacobson*, may be noticed. This is a small tubular sac which is placed on each side of the median septum upon the nasal surface of the palatine plates of the premaxilla and maxilla. Posteriorly it ends blindly, but anteriorly it opens by the incisive foramen into the cavity of the mouth, the mucous membrane of which is continued into it. It receives nerves from the olfactory bulb, which enter into its hinder end and which terminate in structures analogous to the filamentary terminations of the olfactory nerves of the sensory part of the nasal cavity. Though these organs open into the mouth, and not into the nasal fossæ, yet they have an essential relation to the latter, as will appear in the next chapter.

§ **25**. The ORGAN OF SIGHT, the eye, consists, as has been already said, of a globe of more or less soft tissues, into the outer surface of which muscles are inserted—the whole being protected and enclosed, except in front, by dense fascia and muscle, or else by the osseous plates which form the imperfectly closed bony socket or orbit of the eye. Into this ball, moreover, as has already been stated, the optic nerve enters, passing through the optic foramen to its posterior part.

In front, where the bony protection ceases, the ball is protected by an extension of skin above and below, forming the *eyelids* or *palpebræ*. These have their outer surfaces covered by the external skin, while each is lined internally with mucous membrane, and the mucous membranes of both the upper and lower eyelid of each eye are continued one into the other by that transparent membrane which covers the front of the eyeball, and is called the *conjunctiva*. Internally they are strengthened by a strong fibrous membrane.

The *upper eyelid* is raised by the special muscle called the "levator palpebræ," which is supplied by a branch of the oculomotor nerve. A circular sphincter muscle (the orbicularis palpebrarum) extends through both eyelids, and, by its contraction, closes them. There is no special depressor of the lower eyelid. The point on each side where the eyelids unite is termed the *angle*, or *canthus*, of the eye. At its inner canthus are two minute apertures (to receive the lachrymal secretion) called *puncta lachrymalia*. There is also a large fold of membrane, or third eyelid—the *plica semilunaris* or *membrana nictitans*—which rises from the bottom and inner angle of the orbit and rests upon the eyeball. It has a cartilage at its margin which strengthens it (Fig. 130, *MN*).

Immediately beneath the thin delicate outer skin of the eyelids, and adherent to it, are the fibres of the orbicularis muscle, and beneath these are the fibrous membranes of each eyelid (defining its shape and giving it firmness), and then the levator palpebræ muscle. On the inner surface of each lid are certain sebaceous follicles, or tubes, termed *Meibomian glands*, which extend vertically

on the inner surface of each palpebral fibrous membrane. Each tube is lined by mucous membrane, and forms an oily secretion.

The *conjunctiva* is vascular, red, opaque, and somewhat thick where it lines the eyelids, but where it is reflected from them (over the ball of the eye) it is transparent, almost colourless, and has but very few blood-vessels. Over the coloured part of the eye and the pupil, the conjunctiva is quite transparent, and without vessels, and consists almost entirely of epithelium.

The *lachrymal gland*, which secretes the tears, lies at the upper and outer part of the orbit. It is a very small racemose gland, with ducts which open on the inner surface of the upper eyelid, just above the outer canthus. *Tears*, are a clear, saline, alkaline fluid, with a minute portion of albuminoid matter. About 1 per cent. is the quantity of solid matter which they contain. Having traversed the surface of the conjunctiva, the tears enter the puncta lachrymalia (before noticed), which are the orifices of two short membranous canals (the *lachrymal canals*) which pass inwards (towards the nose), and open into a membranous tube, the *nasal duct*, which descends, through the bony lachrymal canal before described, to empty itself into the anterior part of the inferior meatus of the nose. This canal, formed of fibrous and elastic tissue, adheres closely to the bones it adjoins in its passage. It is lined with mucous membrane, which is thus continuous with the conjunctiva above and with that of the nasal fossa below. The epithelium which coats its mucous membrane is ciliated.

The *Harderian gland* is a small organ situated at the inner canthus of the orbit. It is oval and somewhat like a small bunch of grapes. It secretes a thick, whitish fluid, which escapes from one or two orifices which open beneath the membrana nictitans.

The *eyeball* is embedded in fat, from which it is separated by a layer of fascia. It is spheroidal and composed of three investing membranes, one within the other, enclosing certain fluid and solid contents.

The first membrane is the *sclerotic and cornea*, the second is the *choroid* and *iris*, and the third is the *retina*.

The fluid contents is made up of the *aqueous* and *vitreous humours*.

The solid contents is the *lens*, with the capsule enclosing it. The shape of the eye-ball is really that of a large segment of one sphere, with a small segment of a lesser sphere affixed to it in front. The proportion between these spheres is as eleven to seven.

The FIRST OR OUTER MEMBRANE is partly opaque—the SCLEROTIC—while that part of it which is called the CORNEA is transparent.

The SCLEROTIC invests the larger part of the eyeball. It is formed of very dense fibrous tissue, with elastic tissue and with stellate and fusiform nucleated cells. By its solidity and toughness the sclerotic maintains the globe of the eye in its proper shape. It is white externally and smooth, except as regards the insertion of the orbital muscles into it. It is thickest at the back and thinnest near the margin of the cornea. The optic nerve pierces the sclerotic slightly

on the inner side of the antero-posterior axis of the eyeball. The membranous sheath of the whole nerve becomes continuous with the sclerotic, as do also the investments of the different bundles of nerve fibres of which the whole optic nerve is composed. On this account the part of the sclerotic where the fibres enter is called the *lamina cribrosa*. There are a few blood-vessels in the sclerotic, especially near the margin of the cornea.

The CORNEA (or the transparent and anterior part of the fibrous coat of which the sclerotic forms the larger portion) covers the

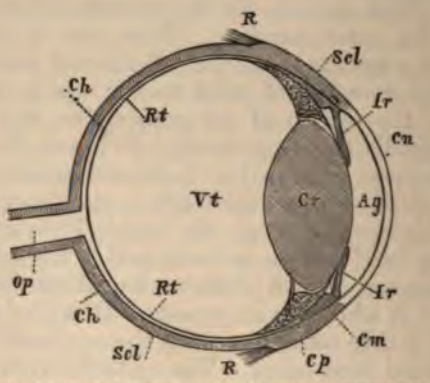


Fig. 134.—DIAGRAM REPRESENTING A VERTICAL SECTION OF THE CAT'S EYE.

Scl. Sclerotic coat.
Cn. Cornea.
R. The attachment of the tendons of the recti muscles.
Ch. The choroid.
Cp. The ciliary processes.
Cm. The ciliary muscle.
Ir. The iris.
Aq. The aqueous humour
Cr. The crystalline lens.
Vt. The vitreous humour.
Rt. The retina.
Op. The optic nerve.

anterior part of the eyeball, and has its surface rather more curved than is that of the sclerotic. It is also composed of fibres which are softer and much more indistinct than those of the sclerotic, with which they are nevertheless continuous, some fibres being opaque at one part of their course and transparent at the other part. Between the layers of fibres there are fusiform nucleated cells. The cornea yields chondrin on boiling, unlike the sclerotic, which yields gelatine. Each surface of the cornea is invested by a most delicate, structureless transparent membrane or elastic lamina.

The SECOND or MEDIAN membrane also consists of two parts: the *choroid* and *iris*. The CHOROID is a membrane placed within the sclerotic, covering the sides and back of the wall of the eyeball, except where the optic nerve pierces it. It extends forwards nearly to the margin of the cornea, where it ends in a number of irregular folds, called *ciliary processes*. These project inwards towards the centre of the eyeball.

The choroid is tough externally where it is connected with the sclerotic by loose connective tissue; internally, it is smooth and dark coloured, being lined by a layer of dark pigment cells everywhere

except at the ends of the ciliary processes, and at a certain considerable part which is called the *tapetum*, and is of a golden yellow colour.* This tapetum is a roundish patch, occupying most of the back of the inside of the choroid, and including within it the entrance of the optic nerve, which enters towards the lower margin of the tapetum. It is this tapetum which gives the eyes of cats that luminous appearance in obscurity, by reflecting the light—a property which is supposed to assist their nocturnal vision. The choroid is an excessively vascular fibrous membrane, the vessels becoming more minute as they advance forwards, and forming a fine capillary network ending very near the margin of the cornea, in what is called the *ciliary* ligament. This ligament is a circular band of connective tissue and organic muscular fibre, which unites the choroid with the sclerotic external to it.

The arteries of the choroid come from the ophthalmic artery. Within the outer vascular layer of the choroid a layer of capillary vessels is distinguished by the name of *tunica Ruyschiana*, or *chorio capillaris*. Within this, again, a structureless (or slightly fibrous) membrane named the *vitreous* layer is described, while inmost of all is the pigmentary layer, of closely placed polygonal pigment cells.

The IRIS is that coloured part of the eye which is apparent around the pupil, and which may be differently coloured on its front surface, in different cats,† but is covered with dark pigment on its hinder or deep surface. It consists of fibrous tissue and organic muscular fibres.

At its outer border the iris is continuous with the choroid and ciliary ligament, and is connected with the cornea, while its free inner border forms the outer margin of the pupil of the eye—it being a sort of curtain with a hole in it, about half an inch across, suspended in the more anterior part of the interior of the eyeball, and resting on the anterior surface of the lens.

The iris is very, and very suddenly, contractile (in spite of the organic nature of its muscular fibres), and has two muscles. The first, or sphincter, is a flat band close to its free inner margin, and on its posterior surface. The dilating muscle, on the other hand, is formed of fibres which pass inwards on all sides towards the margin of the pupil from the circumference of the iris. In obscurity the pupil is widely open, with a circular opening through contraction of the radiating fibres of the iris. In bright light the

* At my request Mr. Henry Power has been so kind as to examine the cat's eye with the ophthalmoscope. As to the result of his examination, after noting the non-appearance of that spot known in man as the *fovea centralis* or yellow spot, he expresses himself as follows:—"I owe you thanks for directing my attention to one of the most beautiful things I have ever seen. Imagine a dense, yet luminous velvety-blackness below, bounded by a nearly horizontal line, *just* above which is a pearly spot; the entrance of the optic nerve. This presents the usual vessels emerging from it. The disc is surrounded by a sapphire blue zone of intense brilliancy, passing into metallic green; and beyond this the tapetum shines out with glorious colours of pink and gold, with a shimmer of blue and of green. It is really lovely."

† Or even in the two eyes of the same cat.

opening contracts more and more till it is reduced to an extremely narrow vertical chink. This is probably due (as has been suggested to me by my friend Mr. Henry Power) to the greater contraction of the superior and inferior radiating fibres than of those which radiate outwards and inwards. A muscle called the *ciliary muscle* consists of a ring of radiating organic fibres which take origin in front from the inner surface of the sclerotic, close to the cornea, and pass outwards and backwards to the choroid membrane, opposite to the ciliary processes. By their contraction these fibres pull forward the choroid, and so render the ciliary ligament less tense. The muscle thus tends to draw the choroid and retina together like a bag round the vitreous body, pressing the lens forwards, which is supposed to be thus indirectly made less flat. There are a few more inwardly situated fibres which run circularly (nearly at right angles to the rest), and form part of the ciliary ligament as before mentioned.

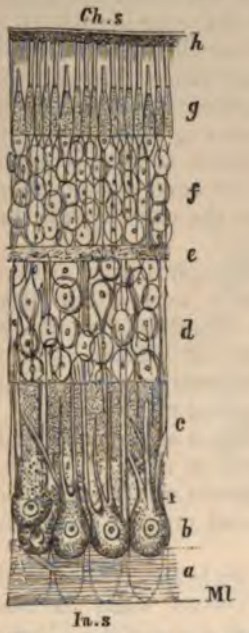



Fig. 135.—Diagram representing a Section of the Retina.

ch. s. Outer, or choroidal surface.
in. s. Inner surface, or that next the vitreous humour.
a. Layer of nerve-fibres at inner surface of retina.
b. Ganglionic layer of large nerve-cells.
c. Inner molecular layer.
d. Inner nuclear layer.
e. Outer molecular (inter-nuclear) layer.
f. Outer nuclear layer.
g. Layer of rods and cones.
h. Layer of pigment cells—next the choroid.
Ml. Membrana limitans.

Inmost of all the coats of the eyeball lies a soft delicate membrane of nervous matter with connective tissue—the RETINA. It extends forwards almost to the ciliary processes, and ends anteriorly in a finely toothed margin called the *ora serrata*, and thence to the tips of those processes the retina is continued on by a transparent layer, the *pars ciliaris retinæ*, consisting of nucleated cells which are not nervous, but part of the *membrana limitans interna*. Slightly on the inner side of the middle of the retina, at the back of the eye, is an oval prominent spot, the *porus opticus*, where the optic nerve enters, and whence the vessels of the retina radiate. This is a blind spot.

The retina is an extremely complex membrane, consisting of about seven layers of different forms of nervous tissue, supported and connected by a most delicate framework of connective tissue.

The outermost layer, that which comes next to the pigment layer just described, is what has been called the membrane of Jacobson. It consists of a multitude of minute and delicate nervous *rods*, placed with their ends directed outwards and inwards. Amongst the rods are scattered at regular intervals a less number of nervous *cones*, placed with their apices outwards.

The rods stand in close apposition. The cones * are not so close et and do not extend as far outwards as do the rods. Both structures ecome shorter as they approach the ora serrata.

Within the rods and cones is a thin layer of granulated substance, onnected with the fibres in which the rods and cones end in- rnally. This layer is the *external granular*, or *outer nuclear layer*, ithin which is the *internal granular*, or *inner nuclear layer*, formed f nucleated cells and fibres, separated from the former by the *inter- ranular*, or *internuclear layer*, formed of plexiform tissue enclosing few nuclei and smooth cells, with oarser fibres running parallel to the urface of the retina.

Within the internal granular layer, gain, is a thicker *inner molecular ayer* (or internal granulated layer), hich contains much connective issue, within which again is a layer f *ganglionic cells*, and lastly and ost internally, is a layer of fibres of he optic nerve, ramifying on the nner surface of the retina, and con- ected with the ganglia placed ex- ernal to it. This layer of nervous ibres is bounded within by an ex- remely delicate, glossy membrane, he *membrana limitans*, which is ontinued forwards as the *pars ciliaris retinæ*, and becomes con- inuous with the suspensory ligament of the lens. Doubtless the ods and cones are continuously though complexly connected with he ganglia and fibres of the innermost layer.

Fig. 136.—LAMINATED STRUCTURE OF THE CRYSTALLINE LENS, SHOWN AFTER HARDENING IN ALCOHOL.

1. Central portion.
2, 2, 2. Concentric lamina, which have become detached along the radiating lines of the external surface of the lens.

At the point of entrance of the optic nerve (*i.e.*, at the blind spot) ods and cones are wanting. In the eye, as in the nose and tongue, he special sense is subserved by minute nervous rods proceeding rom cells.

Filling up the great concavity bounded by the *membrana limitans* ining the innermost layer of the retina is the VITREOUS HUMOUR (or *vitreous body*), forming nearly four-fifths of the ball of the eye. his is a transparent, jelly-like, almost quite fluid mass enclosed (as ust observed) in the membrana limitans of the retina.

The vitreous humour is reducible to water with a few salts and a ittle albumen. It appears to consist of concentric layers of slightly different density, but not separated from one another by any membrane.

The CRYSTALLINE LENS of the eye is a transparent, doubly convex solid structure, interposed between the posterior surface of the

* The cones must be looked upon as collections of nerve terminations; they appear to be longitudinally striated, and they pass into a thick fibre (*cone-fibre*), which consists of a bundle of the finest axis cylinders, which separate in the granular layers of the retina.

iris and the anterior surface of the vitreous humour. It is somewhat harder within than superficially. It consists of albuminous substance and is non-vascular. It is really made up of a multitude of fibres (each a flattened hexagonal prism, about $\frac{1}{3000}$ of an inch wide), with serrated edges and a nucleus. These are so connected that the lens is practically made up of concentric layers of fibres, as becomes evident after immersion in alcohol. The lens is not quite spherical, but is compressed from within outwards, that dimension being less than its transverse diameter.

The *capsule* of the lens is a transparent, glassy membrane, which is very elastic, and closely invests the lens itself. Its anterior surface is in contact with the iris, its posterior surface adjoins the vitreous humour. From the extreme circumference of the lens it sends off a membrane, the *suspensory ligament of the lens*, which becomes continuous with the choroid and with the membrana limitans of the retina, where it has become the *pars ciliaris retinæ*, behind the ciliary processes. It thus divides the chamber in front of the lens from that of the vitreous humour. Just behind that part of it which adjoins the lens, it is slightly separable from the front of the vitreous humour, and when separated leaves a space which has been called the *canal of Petit*, but this is no true persistent canal, but only a yielding interspace affording room for change of place in the lens and consequent focal adjustment.

The AQUEOUS HUMOUR is the fluid which fills the front chamber of the eye between the iris and lens, and the cornea. It scarcely differs in composition from water, but contains some solids in solution—chiefly chloride of sodium. A small portion passes behind the iris, in what is called the posterior chamber of the aqueous humour.

The direction of the eyes is determined, apart from the position of the body, neck, and head, by the ACTION OF THE ORBITAL MUSCLES, of which the *recti* severally pull the cornea in four directions, while the *obliqui* roll the eyeball on its axis, and pull it a little forwards and inwards. The choanoid muscle tends to pull it backwards. The eyelids protect the ball of the eye from foreign substances and from excessive light, and hinder the too rapid evaporation on its surface, the moisture of which is secured by the lachrymal secretion, the superfluous quantity of which escapes to the nose (through the puncta lachrymalia and nasal duct), while the secretion of the Meibomian glands tends to check its overflow beyond the margins of the eyelids.

The structure of the eye, AS AN OPTICAL INSTRUMENT, is that of a camera obscura filled with water, with a circular aperture, behind which is a partition, or *diaphragm*, with another and smaller circular aperture immediately in front of a bi-convex lens.

The lens, according to the laws of optics, concentrates the rays coming from every point in front of it to other points behind it, and thus throws upon any surface situated at due focal distance, an *inverted* image of the objects in front of it. The surface behind,

upon which the image is thrown, is the retina, and the perfection of the image is increased by the iris, which acts like any other diaphragm by moderating the light and cutting off marginal rays, the effect of which, if admitted, would be to produce the imperfection called spherical aberration. The organic fibres of the iris spontaneously act to exclude or admit light through the pupil, which dilates in obscurity and contracts in bright light, in the manner already described.

The different densities of the different media through which the light has to pass in traversing the eye corrects another kind of imperfection due to the scattering of colour, and renders it an *achromatic* instrument.

Not only is the image in the eye inverted, but each eye sees any object from a slightly different point of view. It is this grasp, as it were, of an object on both sides by the two eyes, which gives rise to the apprehension of solidity * and relief.

For distinct vision, the rays of light must be brought to a focus on the retina. Now, without moving the body, neck, or head, the eyes can be so directed alternately to nearer or to more distant objects as to produce distinct perception of each successively. Such movement is the focussing of rays coming from points varying in remoteness. The way in which this adjustment is brought about is supposed to be by the action of the ciliary muscle, and the physical properties of the lens. The latter is highly elastic, and tends to be more convex in front than is ordinarily the case. The ciliary muscle, pulling the choroid, relaxes the ciliary ligament, and therefore the pressure of the capsule on its contained lens, which immediately becomes more convex, and so becomes accommodated to the perception of nearer objects.†

§ **26.** The ORGAN OF HEARING is divisible into three parts: the *external*, the *middle*, and the *internal* ear.

The EXTERNAL EAR consists of a cartilaginous, membranous, and muscular structure, projecting conspicuously upwards from the side of the head, and called the *pinna* or *auricle*, together with the passage leading inwards from the deeply situated lowest portion of the pinna, which passage is the external *meatus*, or tube leading to the internal ear.

The PINNA has the form of the wall of a cone, cut obliquely downwards and outwards from its apex, the section being curved a little upwards at the last, so as to make the lowest part of this conic section almost semicircular. The pinna stands up above and behind the

* It is the special artificial imitation of two such views placed side by side at a suitable distance, which produces the illusion of the *stereoscope*, the relation of each view to its proper eye being maintained. If the views be transposed, so that the view which would naturally present itself to the right eye be presented to the left, and *vice versâ*, as by a *pseudoscope*, then the opposite appearance of a hollow or excavated surface is produced.

† The above is the commonly received doctrine on the subject; but fishes have a ciliary muscle, although the lens in them is globular. It may be, therefore, that its action is not yet correctly understood.

opening of the ear passage. It is deeply concave on the surface, which is turned outwards and forwards, and convex on its inwardly and backwardly-turned surface. It is hairy within and without, but the hairs within are not numerous, though very long. Externally, the pinna is covered with short hairs. Its inner surface presents a variety of prominences and fossæ, which aid in collecting and concentrating the sonorous waves which impinge upon the organ.

Immediately in front and externally, at the bottom of the external opening, is a small rounded prominence, the *tragus*, and immediately opposite it is a double prominence with an intervening concavity, the *anti-tragus*, into the concavity of which the tragus exactly fits. From the anti-tragus a low ridge runs upwards and backwards to the margin of the pinna. A little further in, another similar ridge runs (nearly parallel to that just mentioned) from the margin of the pinna downwards to a very small prominence behind the anti-tragus. Within and behind the tragus there is another vertical undulating ridge, the *post-tragus*, while between its summit and the tragus is a deep, rounded depression.

Behind and above the summit of the post-tragus is the deepest concavity of the concha, from the midst of which a singularly prominent process, with a pedunculated appearance, projects inwards, which process may be called the *supra-tragus*. A slight, short ridge runs downwards and backwards from the lower margin of the fossa in which the supra-tragus is placed. The cartilage of the pinna is large and complexly-shaped, with a reduplication in front. There is a reduplication of skin at the lower part of the posterior margin of the pinna, producing a sort of pouch.

The pinna is attached to two cylindrical cartilages, which follow each other like two successive segments of a telescope, and form the cartilaginous part of the meatus auditorius externus.

A distinct body, called the scutiform cartilage, is only connected with the pinna by ligaments, yet has muscles inserted into it which indirectly move the ear. It lies on the temporal fossa just behind the orbit, with its long axis antero-posterior, and enclosed in pre-auricular aponeurosis. It can glide to and fro in the temporal aponeurosis.

The EXTERNAL AUDITORY MEATUS extends straight in from the PINNA to the drum of the ear, or *tympanic membrane*. Its outer part is formed by cartilage, the rest by bone, as has been before described.* At its inner end the bony tube is grooved at its sides and floor, and into this groove the tympanic membrane is fixed.

The meatus is lined with mucous membrane, which is reflected over the outer surface of the tympanum so as to form a cœcal mucous tube. In the bony part of the meatus this membrane is thin, and closely adherent to the periosteum, but in its cartilaginous part it is thicker, and bears hairs, together with sebaceous and oleaginous glands.

* See *ante*, p. 64.

The MIDDLE PART OF THE EAR, or TYMPANUM, has been already described in part in the description of the temporal bone.* It is a chamber entirely enclosed in the temporal bone, but has certain apertures in its walls. It is separated off from the external meatus by the tympanic membrane, but it communicates with the pharynx through the Eustachian tube.

The *roof* of the tympanum is formed by that portion of the

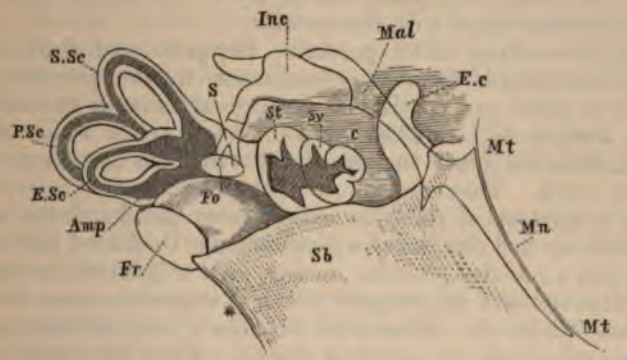


Fig. 7.- SECTION OF THE MIDDLE AND INTERNAL EAR OF THE CAT, MUCH ENLARGED, SHOWING THE MEMBRANOUS LABYRINTH AND ITS RELATIONS (AND THOSE OF THE BONY LABYRINTH) TO THE SEPTUM OF THE BULLA, THE EUSTACHIAN TUBE, AND THE TYMPANIC MEMBRANE. (From a drawing by Mr. Alban Doran.)

The auditory ossicles are represented in outline as if transparent. The septum of the bulla is partly represented, but is cut away at * to show its relation to the labyrinth. The membranous labyrinth is represented by darker shading.

Amp. Ampulla.
C. Cochlea.
E. Opening of Eustachian tube.
E. sc. External horizontal semi-circular canal.
Fr. Fenestra rotunda. (It lies almost entirely above the septum of the bulla and looks into the inner chamber; but its anterior margin bulges into the outer chamber.)
Fo. Fenestra ovalis.
Inc. Incus.
Mal. Malleus.
Mn. Manubrium.
Mt. Mt. Outline of membrana tympani, with manubrium of malleus touching it.
P. Sc. Posterior semi-circular canal.
Sb. Septum of bulla.
S. Sc Superior semi-circular canal.
S. Stapes.
St. Scala tympani of cochlea.
Sv. Scala vestibuli of cochlea.
*. Cut edge of septum of bulla.

petrous bone which immediately adjoins the squamosal. Its *outer wall* has a very large opening closed by the tympanic membrane, and in front of its margin is the inner opening of the *fissura Glaseri*, before mentioned as transmitting the chorda tympani nerve.

The *tympanic membrane*, which is nearly circular, lies obliquely, its outer surface looking somewhat downwards. It is very thin, and consists of fibrous and elastic tissue, the fibres radiating from about its centre, but there are also circular fibres, especially towards its circumference.

The *inner wall* of the tympanum presents several openings and prominences. Towards its upper hinder part is a kidney-shaped or oval foramen called the *fenestra ovalis*. Somewhat in front of the

* See *ante*, p. 68.

fenestra ovalis is a rounded prominence marked by grooves for nerv and called the *promontory*.

Another opening, called the *fenestra rotunda*, lies below a behind the promontory, and is, naturally, closed by membrane.

Above the fenestra ovalis is a small depression or fossa, in whic the stapedius muscle has its organ.

The *anterior part* of the tympanum gradually narrows a becomes the proximal part of the Eustachian tube, which, as befo said, is the canal which places the cavity of the middle part of th ear, in communication with the mouth.

The EUSTACHIAN TUBE proceeds forwards and inwards a slightly downwards from the tympanum to the pharynx. I anterior or distal part consists of cartilage and fibrous membrane.

The tympanum is crossed by four small bones which proce inwards from the inner surface of the tympanic membrane to th fenestra ovalis. These are the AUDITORY OSSICLES.

The outermost of these is called, from its shape, the *malleu* (Fig. 138, B), and consists of a quadrangular thickened portion, th head, with a rounded articular surface (*as*). Adjacent to this is part called the *neck* (*n*), beneath which it expands, on one side, int a lamina of bone (*l*). From this extends a long, delicate, pointe process (*pg*), called the *processus gracilis*. From the inner side o the neck a large process (*pm*) projects, for the tendon of th tensor tympani muscle. Opposite this is a slight prominence, the processus brevis (*pb*), and from between these two last mentioned processes there extends a long curved production, the manubrium (*emn*), which is fixed on the middle of the tympanic membrane.

The second bone is called the *incus* or anvil (Fig. 138, C), also consists of a thickened part, with two processes. The thickened part, or *body*, has a concavo-convex articular surface, which unites with a corresponding surface on the body of the malleus, both surfaces being provided with cartilage united by a synovial membrane.

One process, the *crus breve*, projects backwards, and is attached by ligament to the hinder wall of the tympanum. The other process, the *crus longum*, which is longer, passes downwards behind the manubrium, while its end is bent suddenly inwards and articulates with a third bone, which is a minute rounded ossicle called the *os orbiculare*, and which is generally anchylosed to the end of the crus longum as the so-called *processus lenticularis*. The crus longum articulates by the intervention of the os orbiculare with the fourth auditory ossicle or *stapes* (Fig. 138, D), so called from its resemblance to a stirrup. That portion of it which resembles the part of a stirrup on which the foot rests is called its *base*, and the opposite end its head, while these are connected by the two *crura* which diverge from the *neck*. The base is fixed by ligamentous fibres to the margin of the fenestra ovalis. The space enclosed between the crura and base of the stapes, is naturally closed by a thin membrane. A very small muscle, called the *stapedius*, (to be shortly described) is inserted into the neck of the stapes.

The auditory ossicles are connected with and suspended from the surrounding bones by delicate ligaments.

One such suspends the malleus from the wall of the tympanum, and the incus is similarly suspended, while the stapes is connected by ligament with the margin of the fenestra ovalis.

There are two very small muscles* connected with the auditory ossicles—the tensor tympani and the stapedius.

The *tensor tympani* muscle arises from a pointed process which projects from the free margin of the septum of the bulla as it curves upwards at the posterior wall of the tympanum. This process is sometimes small, sometimes rather long and pointed. The muscle then runs forwards and is inserted into the processus muscularis of the malleus.

Beyond the origin of the tensor tympani the septum curves forwards and upwards and is lost on the promontory a little beyond the fenestra ovalis.

The *stapedius* muscle arises from a more or less deep pit above the fenestra ovalis. It descends almost vertically to be inserted into the neck of the stapes.

The mucous membrane of the tympanum is continuous, through the Eustachian tube, with that of the pharynx, and like it, is clothed with a ciliated epithelium, except where it lines the tympanic membrane. That membrane is, moreover, coated on either side by other membranes, being lined within by the general lining of the tympanic cavity, as it is coated without by the membrane of the external auditory meatus.

The INTERNAL EAR or special auditory part of the organ of hearing is a membranous structure enclosed in an excavation of the petrous part of the temporal bone called the BONY LABYRINTH. This labyrinth consists of three parts, a central chamber, the *vestibule*, connected with a part called the *cochlea* in front, and behind, with another made up of three *semicircular canals*.

The VESTIBULE is a somewhat pyramidal cavity, the front part of the inner wall of which abuts against the bottom of the internal auditory meatus and is pierced by numerous small foramina, which admit the filaments of the auditory nerve. At the front of the lower part of the vestibule is the opening which leads to the cochlea, while the posterior end of the vestibule shows the four openings of the three semi-circular canals. The outer wall of the vestibule is perforated by the fenestra ovalis, which, in the dry skull, opens into the tympanum.

The COCHLEA (Fig. 138, A, *c*) is conical, and has the general form of a limpet shell, with its base directed towards the internal auditory meatus. The cone consists of a spiral tube which tapers as it recedes from its base, winding round a central column (the *modiolus*), the tube being incompletely divided by a lamina of bone, the *lamina*

* The origins and insertions of these muscles have been carefully verified by Mr. Alban Doran.

spiralis, which projects out from the modiolus towards the opposit wall of the tube, except at its apex. It makes three revolution and one quarter of a revolution round the modiolus, its cours being from left to right in the right ear and from right to left i the left ear.

The two divisions of the tube, incompletely separated by th lamina spiralis, are termed "*scalæ*."

The lower of these is called the *scala tympani*, and it commence at the fenestra rotunda. The other division, called the *scala vestibuli*, commences at the ves- tibule, with which it freely com- municates.

Fig. 138.—Bony Labyrinth and Auditory Ossicles (enlarged).

A. Bony labyrinth of the right ear, extracted and reversed in position, its hinder end being placed forwards, and its upper margin downwards.
- *c*. Cochlea.
- c^1. External horizontal semi-circular canal.
- c^2. Posterior vertical semi-circular canal.
- c^3. Anterior vertical semi-circular canal.
- f^1. Fenestra rotunda.
- f^2. Fenestra ovalis.
- *m*. Ampullæ.

B. Malleus.
- *as*. Articular surface of head.
- *n*. Neck.
- *l*. Lamina.
- *pg*. Processus gracilis.
- *pm*. Processus muscularis.
- *pb*. Processus brevis.
- *cm n*. Manubrium.

C. Incus and orbiculare.
- *o*. Crus longum.

D. Stapes.

The semicircular canals are bony tubes extending upwards and backwards from the vestibule from the four openings already mentioned as existing in the posterior part of that cavity.

The tubes describe about two-thirds of a circle each, and may have one end dilated into what is called an *ampulla*, the cavity being considerably increased where such dilatation exists. The three canals receive different names, according to their positions.

The *superior vertical* semicircular canal (Fig. 138 A, c^3) arches upwards and somewhat backwards as well as inwards from the outer side of the skull. It is the presence of this canal which causes a prominence on the upper part of the inner surface of the petrous part of the petrous bone, just above the cerebellar fossa. The more anterior and outer end of this arch is the one that dilates into an ampulla and opens by a distinct aperture. Its posterior and inner end joins with the upper end of the arch next to be described, the two opening into the vestibule by a common aperture.

The *posterior vertical* semicircular canal (c^2) arches backwards and slightly outwards, its upper end starting from the vestibule from an aperture common to it and to the inner end of the superior vertical semicircular canal. Its lower end opens into the vestibule in common with the adjacent end of the *external* or *horizontal* semi-*circular* canal. This last canal arches backwards and outwards and

opens into the vestibule by a distinct aperture, after dilating into an ampulla close to the fenestra ovalis (f^2). Its other end joins, as before said, with the adjacent part of the posterior vertical semicircular canal—the two opening into the vestibule by a common aperture.

Within this osseous labyrinth is the true essential part of the organ of hearing, namely, the MEMBRANOUS LABYRINTH (Fig. 137), which is a very complex, closed sac, corresponding generally in figure with the osseous labyrinth within which it floats. It *floats* because the osseous labyrinth encloses a fluid called the *perilymph*, which fluid surrounds the membranous labyrinth, which itself encloses another fluid called the *endolymph*. Both these fluids are slightly albuminous, and the former, the perilymph, is secreted by a delicate membrane of connective tissue, with a layer of epithelium, which lines the osseous labyrinth and has no communication with the lining of the tympanum (being cut off from that cavity by the membranes which close the fenestræ) though more or less continued into the aqueducts.

The membranous labyrinth consists, like the osseous labyrinth, of three divisions; 1, that of the vestibule; 2, that of the cochlea; and 3, that of the semicircular canals.

That part of the membranous labyrinth which is enclosed in the vestibule, consists of two sacs connected by a narrow bent tube which extends into the aqueductus vestibuli) and containing within them small crystals of carbonate of lime, called *otoliths* or *otoconia*. The more posterior of these sacs is called the UTRICLE, and it is into this that the membranous semicircular canals open by four apertures, corresponding with those of the osseous semicircular canals. The other sac is termed the SACCULE, and a delicate tube proceeding from it extends to and connects it with that part of the membranous labyrinth which extends into the cochlea.

The lamina spiralis of the cochlea has its free edge connected with the opposite wall of the spiral tube by a membrane which completes the separation of the two scalæ except at their summit, where they communicate by a small opening called the *helicotrema*. The membrane which thus completes the partition between the scalæ is called the *basilar membrane*. Another delicate membrane, called the *membrane of Reissner*, proceeds obliquely upwards from the lamina spiralis to the outer wall of the tube diverging in its course from the basilar membrane, and so cutting off a triangular canal from the region above the lamina spiralis. This triangular canal is called the *canalis membranacea* (or scala media), and it is connected by a minute tube (the *canalis reuniens*), with the saccule of which it is a continuation—forming as it does the second or COCHLEAR PART of the membranous labyrinth, and being filled with endolymph. Thus the canalis membranacea ascends the cochlear spiral between the two scalæ—the scala tympani ascending from the fenestra rotunda to the apex, and there communicating with the descending scala vestibuli, which ends in the vestibule.

A very peculiar organ lies in the floor of the canalis membranac
which organ is termed the ORGAN OF CORTI. It lies upon t
basilar membrane, and is covered above by a delicate lamina, t
membrana tectoria. The latter separates the organ from the cav
of the canalis membranacea with its contained endolymph.

Thus this organ, with the basilar membrane below it and t
membrana tectoria above it, forms a thickened floor to the relative
wide canal of the canalis membranacea. The organ itself consi
partly of nucleated cells with stiff hair-like processes, partly
epithelial cells, and partly of two rows (one inner and one outer)
tough rods (compared with cartilage in consistency), so lean
against each other as to enclose beneath them a minute triangu
space between them and the basilar membrane. This long dou

Fig. 139.—A PAIR OF RODS OF CORTI IN SIDE VIEW, HIGHLY MAGNIFIED.

ir. Inner rod.
er. Outer rod.

The nucleated protoplasmic masses at the
of the two rods are also shown resting
the basilar membrane.

thus by decon

continuous with the cells bearing hair-like processes, which have been described as lying beside the rods of the organ of Corti.

Thus here again—as in the organs of sight, smell, and taste—the ultimate structure which ministers to special sense is a system of rod-like filaments proceeding from spheroidal cells.

Apart from the special function of the ear—hearing—the various accessory structures serve the following purposes in aiding that function: the pinna serves to collect the sonorous waves, by its prominences and excavations, and to direct them towards the aperture of the meatus externus. This collecting process is greatly aided by the muscles, which enable the pinna to be turned in various directions. At the bottom of the meatus, the sonorous waves act upon the tympanic membrane, the vibrations of which are conveyed by the auditory ossicles across the tympanum to the fenestra ovalis and so to the perilymph, and, finally, through the walls of the membranous labyrinth,

derived from the air-bladder of fishes. (Treatment of this subject demands a knowledge of the modification of the air-bladder in Amia, Teleosts.)

1884-85.

NATURAL HISTORY 6.

1. What bones in the human skull are composite? Give the position of the separate elements which enter into the composition of each composite bone of the skull.

2. What is the fate of the *os centrale carpi* of the human embryo?

3. Which vertebræ in the human skeleton have costal elements?

4. Describe the shoulder girdle of a man, of a bird, of an iguana lizard (*Cactosaurus*), and of a frog.

5. Compare the mechanism of respiration in a cat and in a frog.

6. Show how the lungs of the terrestrial vertebrata may have been derived from the air-bladder of fishes. (Treatment of this subject

them through a foramen—the internal auditory meatus and the optic foramen. Both contain two internal fluids enveloped by proper membranes—the perilymph and the aqueous humour, and the endolymph and the vitreous humour. Both have a muscular apparatus to regulate the organ according to the quantity of special influence brought to bear upon it—the muscles of the ossicles and of the iris. Both have the action of the special influence intensified by contained hard parts—the otoconia and the lens—and, finally, both have their nerve of special sense expanded and ending in minute filaments on the innermost membrane of their respective structures.

§ **28**. The FUNCTIONS OF THE NERVOUS SYSTEM of the cat are activities the existence and nature of which can be ascertained only: (1) by more or less complex inferences deduced from what human beings can by self-consciousness learn as to their own affections, feelings and cognitions; (2) by conversation; (3) by the observations of pathology; and finally (4) by what can be ascertained as to other creatures by means of experiments upon different animals.

Such inferences and observations show us that not only muscular motion and sensation depend upon nervous influence, but that even such functions as respiration, digestion, secretion, and excretion, are similarly modified, and that the circulation through the body of the nutritive fluid is greatly acted on—acclerated or retarded—by the same influence.

For the perfect performance of all the nervous functions the integrity of the whole nervous system is a generally necessary condition. Nevertheless, partial mutilations of different regions of that system produce very different results, proving that all parts have by no means the same activity, but that *different parts have different functions*, and that some parts are much more necessary than are others to the maintenance of healthy life. When the destruction of any part of the nervous system induces the cessation of some function, the fact of that cessation does not indeed prove that such part is the very organ of such function, but it certainly shows that the non-destruction of such part is a *sine quâ non* for its performance.

Although we find that the powers of sensation and motion are so mixed up in ourselves that, when the body is entire, the existence of the latter involves the occurrence of the former, while any intensity of the former (sensation) produces almost inevitably some amount of the latter (motion); nevertheless observation and experiment prove that in abnormal conditions, either can occur without the other; and the parts which minister to sensation alone or only to motion, are severally named SENSORY or MOTOR parts of the nervous system.

Our consciousness makes plain to us that we not only feel, but that we have very different kinds of feelings. Apart from ordinary common sensation, apart from feeling as to temperature and from visceral feelings, and feelings due to muscular action and the

exertion of effort, there are those special activities we know as sight, smell, hearing, and taste, the SPECIAL SENSES, each absolutely peculiar and incapable of merging the one into the other. Finally, our consciousness shows us that accompanying these various states of activity, there may be either one or other of two accompanying conditions which we call respectively PLEASURE and PAIN.

Certain phenomena which excite the activity of nervous tissue are called STIMULI.

These stimuli may be *mechanical* (as tickling, scratching, pinching, cutting, &c.), or *thermal* (the application of heat or cold, producing a feeling of thermal *change*), or *chemical* (the application of various irritants), or *electrical* (causing a variation in electrical currents),* or finally, stimuli, natural to nervous tissue, and originating in end organs. These natural stimuli may be of two kinds; they may be either (1) *special* (those which affect the organs of special sense, as light, sound, &c.); or (2) *psychical, i.e.*, the presence of certain sensations, emotions, or cognitions.

The presence of any of these stimuli must be of course without effect, unless the nerves acted on by them be in a certain state of *excitability* or impressionability—or, as it is sometimes termed, *neurility*. The long-continued excitation of a nerve will blunt, and ultimately will for a time destroy its power of action. A too prolonged repose also diminishes and ultimately destroys its impressionability, and may at last lead to its transformation into adipose tissue—a change which may also ensue if a nerve be separated from its nervous centre while yet remaining within the body.

We have seen that nervous tissue is of two kinds, fibres and cells, and the activity of the tissue seems also to be of two kinds, namely, *conduction* (or an activity which conducts influences along nerves), and a more positive kind of activity, comparable with the explosion of a mass of gunpowder, to which a train of the same material has conducted a potent influence. It is the fibres which serve as the agents of conduction, and the cells of the grey matter are commonly supposed to produce the more positive kind of activity by some special powers of *receptivity* and reaction which they possess. A familiar example of this conduction and suddenly-active result is the application of a heated substance to the skin, with the result of its sudden withdrawal from such substance through the conduction of some influence inwards from the skin to the source of the motor energy of the muscles, which then produce such recoil. Nerve action is altogether invisible. There is no, as yet observed, visible indication of the active state of a nerve analogous to the shortening of a muscle which indicates myological activity.

What is the NATURE of this NERVOUS ACTIVITY (apart from its results of motion or feeling, or secretion), is a matter of pure speculation. I. It has been compared with the action of electricity,

* The resistance of nerves to electrical conduction is five times as great transversely as in the direction of their length.

of which it has been deemed a special form. II. It has been, and is by many, supposed to be merely one form of physical force—a mode of motion—specially transformed by the molecular structure of the matter through which it passes. III. It has been, and is by many, deemed to be a special kind of vital force peculiar to nerve substance.

As to the first hypothesis, the slow rate at which the nerve impulse travels is alone sufficient to refute it. Whereas light travels at the rate of 40,000 miles in a second, and electricity, along a wire, at the rate of 462,000,000 feet per second—nervous influence appears to pass but at a rate varying from 80 to a little above 200 feet in a second. Again, the interposition of a piece of wire between the cut ends of a bisected nerve does not serve to convey the nervous influences, and cold diminishes, instead of increasing, nervous activity. Moreover, bruising a nerve impedes its action; but no similar effect could be produced on a wire serving for the conveyance of electricity. Moreover, the intensity of nervous action increases according to the length of the nerve it traverses, which is no property of electrical conduction.

As to the second supposition—that nervous activity is merely one condition of physical force—it is but one form of the error which would explain all vital action as physical, in spite of the manifest impossibility of explaining generation, to say nothing of sensation in any such way. But one special hypothesis of the kind is that which views nervous conduction as the serial change of hypothetical nervous molecules from one physical condition to another, nerves being supposed to be made up of parts capable of being easily made to pass to and fro from one physical state to another—as a series of bricks set on end, may be alternately erected and thrown down, the falling of one inducing the fall of its neighbour, and thus carrying on serially an impulse initiated at one end of the series. If such a conception is of any utility, as a working hypothesis to elucidate nervous physiology, there can be no objection to its use, but it must not be supposed to afford any real explanation.

As to the third supposition—that nervous activity is a peculiar vital force—it is again no real explanation, though it is perhaps the most appropriate expression of the facts. It is manifest that the living body is capable of varied activities, and that its several parts exercise functions of different kinds. It is then little more than a truism to say that nervous tissue is the seat of nervous force. It is unquestionable that its integrity and stimulation are the conditions *sine quâ non* for the manifestation of all the highest animal activities, while different degrees and kinds of injury inflicted on it result in different degrees and kinds of impairment of such activities, and, when carried beyond a certain point, end in the destruction of all vital activities whatever—even of the merely vegetative or organic activities. Nervous activity then is the vital activity of a living organism as it energizes in its nervous system. But the conception *of a particular* kind of vital force must stand or fall with the con-

ception of FORCE itself, of which so much has been made by popular teachers of our day. Force, indeed, has been, and is, constantly spoken of as if it were a substance; as if indeed it were the only substance. But to plain minds, as well as to followers of the highest philosophy—that of Aristotle—that which exists, as manifested to our senses, is the external world of visible, audible, tangible, sapid or odorous substances, which substances indeed possess many active powers. Force is in reality but an abstraction; it does not exist either for our senses or our reason apart from substances, and is the name applied to the activities of such substances considered abstractedly from the acting substances themselves. A living body is a special substantial whole made up of parts, and both the whole and its parts have various active powers, and the active powers of animals, energizing through the nervous system are really what is meant by the abstract term "nervous vital force."

§ **29**. We may now pass to the consideration of the functions of the different parts of the nervous system. Before doing so, however, it should be observed that certain CONDITIONS are NECESSARY for the continued exercise of all nervous activity.

Thus the *temperature* of the body must be moderate, certainly not less than about 72°, or more than about 120°. The nervous tissue must also be adequately supplied with *blood*. This blood must be *sufficiently oxygenated*, and also devoid of poisonous matter, such, *e.g.*, as that with which it becomes charged from a cessation of the renal secretion. Finally, the continuity of the more important nervous structures must be maintained.

§ **30**. The FUNCTIONS OF THE SPINAL NERVES are manifestly both sensory and motor, according to their distributions and connexions. If one of these nerves be divided and the cut end of its distal part be irritated, motion ensues in the muscles to which such nerve is distributed, but no pain ensues from such irritation. If, on the other hand, the cut end of its proximal part be irritated, pain is caused, but not motion. If the posterior root of a spinal nerve be alone severed, the parts supplied with twigs from such nerve only lose their sensibility, but their power of motion remains. If, on the other hand, the anterior root of a spinal nerve be alone divided, then the parts supplied by such nerve are paralyzed as to motion, but nevertheless retain their sensibility.

It has therefore been concluded that all the nerves conveying influence inwards, and centrally (called *afferent* nerves, and giving rise to sensation), pass through the posterior roots of the spinal nerves exclusively, and that the fibres which convey motor influence outwards and peripherally (called efferent nerves), pass through the anterior roots of the spinal nerves exclusively—the two sets being mingled at and beyond the point of junction between the roots, but sensory and motor fibres being distributed in the ramifications of each spinal nerve. It has been further assumed that the nerves themselves neither feel nor initiate motion, but that both feelings and motor impulses arise in the grey matter of the nervous

centres, with which the internal ends of the efferent and afferent fibres—internal end organs—are connected.

This opinion has been reinforced by the fact that after severe injuries to the spinal cord, parts supplied with nerves which take origin below such injury, become deprived both of sensibility and of the power of voluntary motion, while irritation of the cut surface of the proximal part of a divided nerve in a limb stump may produce a sensation, which feels as if it took place in parts which no longer exist—as, *e.g.*, in the toes, when the leg has been amputated. But in fact these phenomena are susceptible of another explanation, and one which admits the belief that sensation occurs there where it appears to occur—and not far away in the central part of the nervous system. For as the completion of the electrical or magnetic circuit is necessary for electric or magnetic discharge, so a certain integrity of the nervous structure is necessary for the result of nervous action in motion or sensation, even though such sensation really take place at that part of the body where it seems to be felt. When, however, the integrity of the nervous structures is impaired, the motor or sensitive nervous activity is correspondingly impaired, and the occurrence of non-natural and abnormal sensations might be *à priori* expected to arise under such non-natural and abnormal structural conditions. The occurrence of abnormal and more or less delusive feelings after structural injury, by no means proves that sensation is not peripheral under normal conditions. It only proves that while nervous integrity is a *sine quâ non* of normal sensation, it is not a condition for the occurrence of all sensation, but admits of the occurrence of feelings of an abnormal and accidentally delusive character.

It has also been very often assumed and supposed that the distinctions between the functions of nerves (*i.e.*, whether they are sensitive or motor) is due to some special endowment of the nerves themselves, and not merely to the connexions which they may happen to have. Now, however, it seems more probable that most, if not all, nerves are essentially similar as regards their own intrinsic powers, but that different nerves have practically different functions, because their connexions are different. According to this view, any nerve going from a nervous centre to a gland must have for its function the promotion of secretion; any nerve going from a centre to a muscle must have for its function the production of motion, and any nerve going from a peripheral end organ to a centre must have for its function either the promotion of sensation or reflex action.

Whether this view be or be not correct, nerves, as we actually find them, are either centripetal or centrifugal in their action, and, as a rule, nervous influence can only be propagated in one direction in any particular nerve. It may be that some nerves are inhibiting ones, *i.e.*, they are nerves which proceed from centres to the vicinity of other nerves, and, by their influence, check or neutralize the actions of the latter.

§ **31.** The so called FUNCTIONS of particular nerves are then partly learned through their distribution, partly through experiments, and partly by the very simplest observations. Those of the CRANIAL NERVES, for instance, which minister to special sense, are plainly and obviously distinguishable from all others. Mechanical stimulation of the optic or auditory nerves does not produce pain, but only certain sensations either of light or noise. Division of the various cranial nerves causes paralysis or insensibility, or both, to the parts they supply, in accordance with their distribution and what has already been said as to their several functions.

Thus, division of the seventh nerve causes distortion of the mouth from paralysis of the muscles of the face, except those supplied by the fifth nerve.

The integrity of the pneumogastric nerve is needed for the experience of the sensations of oppression from want of air, of irritation in the air passages, of hunger, thirst, &c., as also for the due performance of the functions of the parts supplied by it. Thus its division paralyses the movements of the stomach (so that food is only digested at its surface,) and diminishes its secreting power, as well as that of the liver, and renders deglutition impossible—finally even producing suffocation. Yet it accelerates the action of the heart, which is, on the contrary, impeded or stopped by irritation of the pneumogastric, so that it seems that this nerve acts normally as a check on the heart's action. Division of the spinal accessory nerves paralyses the action of swallowing and also of the laryngeal apparatus and so destroys the voice, though the respiration action (being under the influence of the pneumogastric) continues. Division of the hypoglossal nerves, of course, paralyses the tongue. A short summary of the functions of all the cranial nerves has been already * given.

§ **32.** The FUNCTION OF THE SPINAL CORD is commonly considered to be merely a conductor of both sensitive influence to the brain and of motor (especially of voluntary) influence from it; and this is no doubt true in a certain sense. Thus it is true that the transmission of some influence up it to the brain is a necessary condition to the experience of sensation, and that the transmission of some influence down it from the brain is a necessary antecedent to voluntary motion; but it does not by any means follow, as is often supposed, that on this account sensation and voluntary action are to be considered as really localized in the brain because of the necessity of the intervention of that organ in order to their experience. Though, no doubt, what are practically the centres for complicated motions, are in the brain.

With this proviso, we may treat, in the ordinary way, of the *paths* which these influences seem to follow in traversing the spinal cord. It is almost certain that both are predominantly situated in the white fibres. It appears from recent experiments that both *motor* and *sensory* impulses ascend and descend through the *lateral columns*, the special functions of the anterior and posterior columns being unknown.

* *See ante*, § 16, p. 275.

If the spinal cord be cut through, it is impossible for the injured animal either to feel any irritation which may be applied to parts the nerves of which take origin below the division, or by any voluntary effort to move any such parts. Nevertheless movements of such parts may be produced by stimuli applied to them, without the occurrence of either conscious sensation or voluntary effort. Such unconscious movement in response to unrecognized stimuli is called REFLEX ACTION. This shows that the cord itself must be a centre capable of initiating responsive action—of turning, as it were, unfelt sensitive impulse into involuntary motor impulse. It does, in fact, that which the brain does; but does it, at least when thus mutilated, without the accompaniment of any perceived sensation. This kind of action is also called *automatic* or *excito-motor*, and it is a curious fact that responsive movements of this kind are more energetic than they would normally be, owing possibly to the spinal centres being entirely devoted to the reflex action, and not at all by the transmission of influence to the brain.

But reflex action may take place in the uninjured condition, as during sleep or under the influence of chloroform. Even when awake the sudden and involuntary withdrawal of the foot from an irritating object is an instance of essentially the same kind of action, though since sensation here intervenes, such an action is spoken of as *sensori-motor*, and is not exclusively due to the action of the spinal cord. But, in fact, all action is "reflex" in the widest sense of that term, *i.e.*, including sensori-motor action. For all animal actions which do not result from unfelt stimuli (internal or external) result from felt stimuli.

SENSATIONS are capable of RADIATION OR TRANSFERENCE, as where disease in the hip may produce pain in the knee-joint, or as, during neuralgia, when pain proceeds from the part supplied by one branch of a nerve to parts supplied by other of its branches.

§ **33.** As to the FUNCTIONS of the MEDULLA OBLONGATA, it appears to *transmit* and *transfer* influences in essentially the same way as the spinal cord does—as when irritation of the stomach produces headache, or when pain in one tooth results in pain in the corresponding tooth of the other side. The sensory impulses proceed through the restiform bodies (which are extremely sensitive to touch) and the motor ones, through the anterior pyramids. The division of either pyramid results in motor paralysis, but, owing to the decussation of their fibres, a paralysis of the side of the body *opposite* to that of the division, supposing the cut to be made *above* the place of decussation. Similarly, paralysis of the opposite side of the body follows from destruction of one half of the encephalon above such decussation. The function of the olivary bodies is unknown.

The medulla is the seat of many *reflex* actions, such, *e.g.*, as sneezing, coughing, closing the eyelids, swallowing, and the respiratory actions. After the insensibility produced from concussion of the brain or from chloroform, food placed far back in the mouth will be swallowed and respiration will be still carried on. Indeed, in

the frog, respiration will continue if the medulla be left intact, even though the brain and the spinal cord have both been removed, while destruction of the medulla oblongata immediately arrests it. Injury to a limited region of the floor of the fourth ventricle causes sudden cessation of respiration and instant death in warm-blooded animals. The fact that so many cranial nerves have their deep origins in this part of the cerebro-spinal axis, sufficiently explains the extensive character of its excito-motor and sensori-motor activities. Indeed this part may be supposed to serve as the organ of the common sense, *i.e.*, of that sense by which the several senses come into relation one with another and are felt as diverse modifications of one sentient being.

§ **34.** The FUNCTIONS of the PONS VAROLII are, at least, in part similar to the conducting functions of the medulla—the central grey and white portions of both being continuous. Animals deprived of both cerebrum and cerebellum, but with the medulla and pons intact, remain motionless if undisturbed, but if disturbed move themselves into postures of stable equilibrium, which they seem incapable of doing if the pons be removed, although the medulla be left.

If the fibres passing from the pons to the cerebellum on one side be cut through, the injured animal's body begins to rotate towards the injured side, the eyeball of the injured side moving downwards, while the eye of the opposite side rolls convulsively.

The FUNCTIONS of the CORPORA QUADRIGEMINA are closely connected with the sense of sight, since not only their destruction causes blindness and immobility in the iris, but they often waste after atrophy of the eyes. The destruction of one side of this structure causes blindness in the *opposite* eye.

The OPTIC THALAMI are also thought to be concerned in sight, yet this sense may persist after their destruction. They are by many supposed to form the anterior termination of the sensory tract of the cerebro-spinal axis and to be the organ of the common sense, which sense, however, may perhaps be more fitly attributed to the medulla oblongata. There is evidence that they have to do with the power of supporting the body on the limbs, as this power may remain after the destruction of the corpora striata, but ceases after the removal of the optic thalami.

The CORPORA STRIATA are similarly deemed by many to form the anterior termination of the motor tract of the cerebro-spinal axis and to convey downwards from the cerebrum impulses resulting from the grouping of images attributed to the cerebral hemispheres.

The CEREBELLUM has had a variety of FUNCTIONS assigned to it, but its real office is still unascertained. It has been supposed to co-ordinate the muscular movements, or to specially direct the muscles of the eyes, or to be the organ of space relations generally, or finally, to be the seat of the sexual emotion.

On the whole it appears probable that the cerebellum ministers to complex and co-ordinated muscular movements. Such a conclusion seems to result from pathological facts and vivisections: animals

being unable to rise after they have been thrown down if the cerebellum has been removed. The greatest caution however is needed in concluding from negative facts, and, as yet, it cannot be safely affirmed what is the true and special function of this remarkable organ, the predominant connexions of which are with the spinal cord and not with the brain.

§ **35**. The true FUNCTIONS of the CEREBRUM are also far from being satisfactorily known. It has been generally regarded as the organ of cognition, and it is abundantly proved that the destruction of both the cerebral hemispheres puts an end to all manifestations of intelligence, so that this view may be to a certain extent accepted. Recent experiments also tend to make the opinion probable, that certain of its surface regions are related to the five special senses. But similar experiments have also shown that the electrical stimulation of different parts of the cerebrum will cause different movements. Such movements, however, may after all be due in fact to the necessarily induced irritation of more deeply seated parts by the unavoidable diffusion of currents. It seems, however, to be fully proved that the cerebrum has a great deal to do with motion, and is an important motor centre. It may be that by its sensory and motor connexions it ministers to that sense of effort, and to those feelings of different kinds and degrees of effort which are often spoken of (perhaps unfortunately) as the "muscular sense," and to feelings of movement. For the present, however, the true functions of the cerebrum cannot be said to be known, although they afford abundant matter for more or less ingenious speculation.

§ **36**. The FUNCTIONS of the SYMPATHETIC SYSTEM relate to the performance of the organic functions of the body, and especially regulate the activities of the viscera.

On account however of the multifold and intimate connexions of this system with the cerebro-spinal system, it has been as yet impossible certainly to determine what activities are truly under the control of the sympathetic. Normally its actions do not give rise to sensation, though in unhealthy conditions pain may accompany them. The presence of ganglia and afferent and efferent fibres renders it in the highest degree probable that some sympathetic nervous action is of the reflex order,—complete in itself and more or less independent of the cerebro-spinal system. The action of the sympathetic, by stimulating the secretion of glands, may call into play instinctive actions and stimulate emotions. Both *secretion* and *nutrition* are greatly influenced by the sympathetic, but this may be, but indirectly, owing to alteration of the calibre of the arteries by the influence of the vaso-motor nerves. Such of the arteries as are supplied from any particular branch of the sympathetic become dilated when that particular branch is cut. It is supposed that the action of the vaso-motor nerves (derived partly from the sympathetic, partly from the cerebro-spinal system,) is to keep the muscular coats *of the* arteries moderately contracted, and that, therefore, when the

action of these nerves is paralysed (as, *e.g.*, by division) the arteries they supply dilate, and in this way increased sensibility and secreting power is promoted by the greater supply of blood thus induced. Some physiologists, however, explain this dilatation as a positive instead of a negative action.

The nervous sytem is, as we have seen, *bilateral*, but between the two halves of its central part there are, as we have also seen, numerous transverse commissural structures and decussating fibres. The correspondence of function with structure in this respect is shown by those cases, already given, in which injury or stimulation of one side of the central nervous system produces effects on the opposite side of the body. That the cerebral hemispheres are each capable of carrying on all the activities requisite for cognition is proved by the fact that the destruction of one does not necessarily even impair cognitive activity. It may seem strange that with the presence of a double organ of such a special nature, processes of cognition and feeling should be, as they are, single ; but, in fact, there is no greater wonder in cognizing singly by two similar hemispheres than in seeing singly through two similar eyes.

§ **37.** A phenomenon that may not unfitly be here noticed, is SLEEP, since during it the central nervous system, or part of it, undergoes a temporary suspension of its activity. It is the cerebrum and the sensory centres which thus periodically intermit their action. Certain parts, however, of the nervous centres never sleep, as is the case with those which govern the unceasing respiratory actions, as also those parts of it which minister to all the functions of vegetative life. Yet, although thus continued, the frequency of the respiratory and circulating movements, diminishes, and the temperature of the body is consequently lowered. The quantity of the blood in the brain is by some persons supposed to be diminished during sleep. Before the daily period of repose is reached, the activity of the nervous system has generally already been so taxed that it no longer responds with thorough readiness to stimuli. With the assumption of an attitude of rest, and with the closing of the eyes, this torpidity increases, till it ends in more or less complete repose. Sleep gradually counteracts the effects of previous activity, and in consequence the readiness to respond to stimuli becomes progressively greater as sleep continues, till the occurrence of some very slight exciting cause suffices to awake the dormant animal. Apart, however, from any exhaustion from fatigue, the cat generally falls asleep with remarkable readiness at any hour (when not disturbed by hunger or passion), as soon as it has become quiescent.

§ **38.** Before concluding this account of the functions of the nervous system by saying what remains to be said of the several special senses, certain remarks may be made with respect to SENSATION IN GENERAL.

Sensations are of two classes, *external* and *internal*. The former are produced by the agency of external bodies, the latter by the body itself. They may both exist simultaneously, as when one part

of the body presses on another. For the experience of sensation at all the presence of a nerve is a necessary condition, and for the exercise of special sensations we require special conditions of special nerves. Sensations are not momentary, but persist more or less as after effects, as may readily be perceived by first looking at the sun or any very bright object, and then looking at any duller object, when a dark spot, or spectrum, will be visible, resembling in shape the bright object previously looked at.

Frequent and continued repetition of the act of sensation diminishes through exhaustion the sensitive power, but moderate, habitual exercise of any faculty of sense tends to develope and perfect it.

The *special sensitive faculties* are each *sui generis*, nor can one merge in another, nor all in any common power of sensation. Thus, before any special sense can exist or act, it must be present potentially, *i.e.*, it must be innate. Each special sense is elicited in a manner totally unknown. If we count up all the number of sensations which differ in kind, their number will be seen to be considerable. Thus we have perception of change of *temperature*, the sense of *internal effort and resistance* (the so-called muscular sense), the sense of *hunger*, *thirst*, *fatigue*, *sickness*, and finally we have the two very peculiar phenomena—*pleasure* and *pain*, and the faculties, touch, taste, smell, sight and hearing, commonly called the special senses *par excellence*. All the special sensitive faculties, however, may be deemed to have a relation of similarity with touch, and in each, as we have seen, delicate nervous filaments are exposed in some special manner to receive a stimulation of a peculiar kind.

The feelings above enumerated are felt in different parts of the body, nor are those persons who deny that they are really felt where they seem to be felt, able to establish that they are actually felt in any other place.

As to pleasure and pain, they are feelings of a special and unanalyzable kind which accompany (either one or the other) in a greater or lesser degree all other feelings. The healthy performance of the bodily functions, when felt at all, is pleasurable. Hindrances to, or irregularities in, their performance are commonly painful. With many exceptions and variations, it may be said that pleasurable sensations tend to guide to actions which are profitable to the organism, and painful ones to deter from such as are injurious.

The SENSE OF TOUCH in its simplest form is a feeling of *contact*; by intensifying this feeling we get feelings of *resistance*, *density*, *hardness*, *softness*, &c. By employing movement in addition, *size*, *distance* and *figure* become appreciated, and the nature of surfaces, as *e.g.*, their roughness, smoothness, &c.

The delicacy of touch, as perceived by the skin, varies much in different parts, as we have seen. These differences are doubtless related to the differences in the number of nerve fibres supplied to the different parts.

Impressions received by touch become associated with other ones, and cohere in more or less complex aggregations, which may be

retained in the sensitive memory, cohering and being retained the more firmly, the more frequently they are repeated.

The *sense of taste* can only be exercised upon matters in a state of solution. It is closely connected with the sense of smell, insomuch that various flavours, which are commonly supposed to be perceived through taste, become imperceptible if no use be made of the sense of smell. Sight even has its effect upon taste, as the relish for various pleasant tasting substances may be diminished by darkness. This sense is very capable of education, and pleasurable feelings can be induced by perseverance with respect to substances which are at first distasteful. One kind of taste will for a time paralyze the power of appreciation of other flavours, while, *per contra*, certain tastes (*e.g.*, wine and cheese) reciprocally stimulate the intensity of gustatory sensations they respectively give rise to. After-tastes are sometimes observed, such as a taste of sweetness following the intensely bitter taste of tannin.

The *sense of smell* needs for its exercise the presence of some influence in the air drawn in through the nostrils, the Schneiderian membrane being moist and the olfactory nerves in a normal condition. Olfactory impressions do not persist as long as do those of taste, and of course much less than those of touch, but they are very delicate, a $\frac{1}{13,000,000}$ part of musk being perceptible when mixed with common air. The sense of smell can be strengthened by use, and it tends to act both as a deterrent and also as a guide to what is attractive to the organism. Odours become easily associated in memory with sensations of other kinds, so that a recurrence of a smell will often recall the latter. Smell may be considered as guarding respiration, as so many noxious atmospheric conditions are attended with disagreeable odours.

The *sense of hearing* gives information as to the intensity, quality, and direction of sounds. It has been a widely received doctrine that the nerve-branches supplied to the semi-circular canals enable us to appreciate the direction of the sounds heard, while the cochlear filaments serve to make known the qualities of sounds; these are purely speculative opinions, and their truth cannot be relied on.

The *sense of sight*, as regards the mechanism of its organ, has been already explained. It remains but to speak of the curious fact that the co-existence of inverted images on the back of two eyes produces but a single perception of an external world which is not inverted. This phenomenon has been explained by attributing the exercise of sight not to the eyes themselves, but to certain of the grey masses within the cerebrum, or to the corpora quadrigemina. It is, however, to say the least, no less inexplicable that such interior grey masses should be the seat of sight, than that the retina itself should be that seat. It is objected that irritation of the cut optic nerve produces a sense of light, and it is thence argued that perception of light must be interior, as also that in persons who have lost their eyes, diseased conditions may produce spectral illusions. But to such objections it may be replied (analogously to the reply before

made as to a similar objection with respect to the spinal nerves)—that we willingly admit the possibility that the excitation of a large fragment of the organ of vision, may produce a fragmentary sensible perception, as also that the grey matter of the interior roots of the organ plays an important part in eliciting the act of sensation, but these admissions do not render it any less rational to suppose that when the whole organic circuit is normal and complete, the animal really sees both in and with its eyes.*

As to the perception of distance and direction, it may well be that the perceptions of all the special senses besides touch, *i.e.*, colour, sound, taste and smell, can only be localised, not by the nerves of special sense, but by the help of those branches of the fifth nerve —a nerve of ordinary sensation—which go to those organs.

The functions of the nervous system may then be summarized as follows:—

It presides over, stimulates and regulates the alimentary, circulating, respiratory, glandular and reproductive processes of the body; it induces appropriate response to stimuli which are unfelt (reflex action) and to felt stimuli (sensori-motor action); it regulates all the muscular contractions which result in motion, and finally it ministers to all those modifications of "feeling" and all those complex associations and complications of feelings known as imagination, memory, emotion and cognition, to which reference will again be made in the chapter on Psychology.

* As the different end-organs of the retina perceive different colours, either each such end-organ must be devoted to the perception of one colour only, or else each must be capable of stimulation by stimuli which are qualitatively different.

CHAPTER X.

THE DEVELOPMENT OF THE CAT.

§ 1. By "the development of the cat" is signified the sum of those rapidly succeeding morphological and physiological changes which commence the life history of the animal. They are changes of great importance and significance—changes in the very nature of the creature undergoing them, as well as in the forms and relations of the different parts of the body which successively come into existence. Each individual of the species upon attaining majority, naturally develops one or other of those two products which have been described in the eighth chapter—ova and spermatozoa.

We may consider the formation of these products as the culmination of the individual's development, and we may consider the conjunction of those products as the initiation of another individual's life. The series of changes, then, which make up the cat's life history, is a series which tends (the requisite conditions being supplied) to return in a cycle. The impregnated ovum becomes, as we shall see, an embryo; the embryo, a fœtus; the fœtus, a kitten; and the kitten, a cat, destined to give rise to, or to fertilize, another ovum like that with which this cycle of changes began. By the cat's "development," then, should be meant the entire sum of changes it undergoes, from its condition as an impregnated ovum till maturity; but practically it has come to mean (as above said) that early part of the process which takes place up to, and till shortly after, birth. Thenceforward the changes which ensue are less changes in the forms and relations, than in the dimensions of parts; and the process of "development" becomes mainly a process of "growth."

§ 2. But the ovum undergoes certain initial changes, even before impregnation takes place, which changes may nevertheless be regarded as a part of the developmental process. Such changes, however, as well as some others (especially those of the earliest stages of development after impregnation), have not been actually witnessed in the cat's ovum. Nevertheless, the analogies of animals generally, on the one hand, and of animals nearly allied to the cat on the other, make it possible to infer what those changes in all probability are.

The ovum having attained to the condition already described in

the eighth chapter,* with its yelk, zona pellucida, germinal vesicle and spot, the first change preparatory to impregnation is the rupture of the Graafian follicle. Having been cast forth from that follicle and entered the Fallopian tube, the ovum spontaneously begins the developmental process itself. Its nucleus, or germinal vesicle, approaches the surface of the ovum, and its outline becomes irregular or obscure. Having reached the surface, one or two portions of its substance, called *polar vesicles*, are extruded through it from the ovum. The remnant of the germinal vesicle then returns towards the centre of the ovum, and constitutes the *central*, or so-called "*female*" *pronucleus*. It probably contains a nucleolus, and the protoplasm of the ovum becomes radiately striated around it.

All is ready now for the act of impregnation.

§ **3.** The spermatozoa having advanced to the ovum (for by their vibratile action they can make their way up the uterine cornua and Fallopian tubes), no sooner meet with it, than they plunge in to its outer transparent coat, and one spermatozoon (possibly,† but probably, more than one) actually bores its way through, and plunges its head into the substance of the ovum. That substance itself, however, is not altogether passive, for a small prominence may arise from its surface to meet the incoming spermatozoon. Immediately this contact has taken place, the outermost layer of the ovum's protoplasm may separate itself off as a distinct membrane, and so form the way to the entrance of other spermatozoa.

The head of the spermatozoon having thus entered the ovum, it constitutes there a second *peripheral* or "*male*" *pronucleus*. This advances towards the centre of the ovum, the protoplasm of which assumes a radiate arrangement round it. Then the two pronuclei are attracted towards each other and meet and fuse into a single body called the "*first segmentation nucleus* (Fig. 141, A). This nucleus has thus been formed by two corresponding parts from the male and female organisms respectively. For the female pronucleus is a portion of the nucleus of a *germ cell*, the whole of which has become modified into the ovum, while the male pronucleus is a spermatozoon, which is a part of the nucleus of the original *sperm-cell*, which divided to form spermatozoa. We have therefore in the first segmentation nucleus, what must rank as a true nucleus of complex nature and diverse origin—an original from two equivalent and complementary parts.

§ **4.** The next step in the process of development is that known as the SEGMENTATION OF THE YELK, or vitellus, *i.e.*, of the protoplasm of the ovum. The first segmentation nucleus gradually elongates, becomes medianly constricted, and divides into two secondary *segmentation*

* See *ante*, p. 250.

† There is as yet much divergence of opinion on this matter, and some observers even maintain that the entrance of more than one spermatozoon is an *occasion* of monstrosity in the embryo. The reader will find a full statement and discussion of these views in Mr. Balfour's excellent Treatise on Comparative Embryology, vol. i., 1880, p. 67.

nuclei, and the protoplasm of the ovum also divides, arrangin around each secondary segmentation nucleus. The two hal not quite equal in size. One, larger and more transparen 141, B, *e*) is the *ectodermic* or *epiblastic* sphere, the other (*i endodermic* or *hypoblastic* sphere. Each sphere again sub and the same process is repeated with each subdivision, ther thus four spheres, or cells, derived from the primitive ep sphere, and four from the primitive hypoblastic sphere. these latter now assumes a central position (Fig. 141, C) process of division is then continued, but unequally, the cells from the epiblastic sphere dividing more rapidly, and theref coming smaller than these from the hypoblastic sphere. M

Fig. 141.—YELK SEGMENTATION.

A. Impregnated ovum, with a single segmentation nucleus.
h. External envelope.
z. Zona pellucida, with spermatozoa.
n. Segmentation nucleus.
y. Protoplasm or yelk of the ovum.

B. Ovum, with the yelk divided cleavage cells, each with its nucl
e. Epiblastic cleavage cell.
i. Hypoblastic cleavage cell.

C. Fourth segmention into eight epiblastic and four hypoblastic.

the epiblastic cells come to surround and enclose the hyp cells, save, perhaps, at one point where the hypoblastic ce appear at the surface (Fig. 142). The mass of cells, howeve a solid whole. There is no central cavity. Soon, however, space appears, and liquid forms between the mass of hypobla and the epiblastic cells (Fig. 143, A), save at one part wh two sets of cells adhere together. This process rapidly conti the ovum grows, the interspace becoming wider and wider, til we have a relatively large sphere of very small epiblastic cells, the inside of one part of which the aggregation of small hyp cells is flattened out, so that we have a double stratum of cells, ing of a single layer of hypoblastic cells beneath a single laye blastic cells (Fig. 143, B). In other words, we have two membranes—an epiblast and a hypoblast—the epiblast i the whole ovum within the vitelline membrane, the hypoblast lying only a portion, though a considerable portion, of the The cellular membrane thus investing the ovum, and deriv the segmentation of the yelk, is called the *blastoderm*, whole structure is the *blastodermic vesicle*. That part where

membranes coexist is the germ area, or *gastrodisc*. In the cent[illegible]tral portion of this, a third membrane soon makes its appearance (F[illegible]ig. 144). This is the *mesobla*[illegible]ast and is thought to be deriv[illegible]ive from the hypoblast,* by su[illegible] divisions of the cells of t[illegible] letter. The three-layered p[illegible] of the gastrodisc is a mu[illegible] thickened part of it, and [illegible] called the *embryonal area*, for [illegible] is here that the embryo arise[illegible]

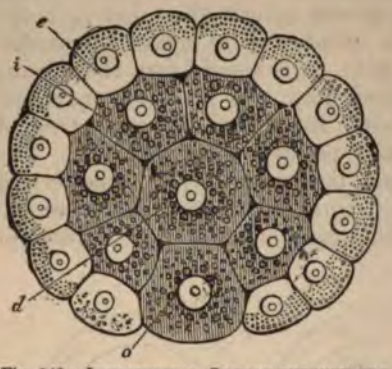


Fig. 142.—Longitudinal Section through the Axis of the Ovum, in which the Epiblastic Cells (*e*) have almost surrounded the Hypoblastic ones (*i*).

d. Central cell.
o. Hypoblastic cell, occupying the interspace left at one point by the epiblastic cells.

Up to this point the matt[illegible] which is eventually to becom[illegible] the body of a cat shows no [illegible] semblance to any animal wh[illegible] ever. It is but an aggregati[illegible] of cells of protoplasm arrang[illegible] as just described, and is rath[illegible] comparable with some ve[illegible] lowly organised fungus-like pl[illegible] than with anything we or[illegible]rdinarily understand as an ani[illegible]mal.

§ 5. It is in the midst of the embryonal area that the first s[illegible]sign of the cat which is to be, is made manifest by the FIRST APPEARA[illegible]NCE

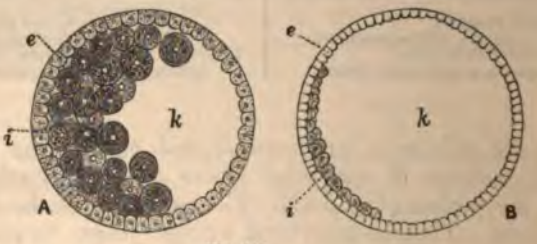


Fig. 143.

A. Commencing separation between the epiblastic and hypoblastic cells.
e. Epiblast.
i. Hypoblast.
k. Cavity formed by the separation.

B. Completion of the process, and forma[illegible] a germ area, or gastro-disc, of two la[illegible] one (*e*) of epiblastic cells, the other hypoblastic cells.

OF THE EMBRYO. The first indication of the embryo is the app[illegible]ance of a longitudinal depression or furrow, termed the *medull*[illegible] *groove* (Fig. 145), and it is the sign of the appearance of the m[illegible] important and central of all the organs of the future animal, fo[illegible]

* In a paper read before the Royal Society on March 23, 1876, Mr. E. A. Schäfer describes the formation of a membrane in the cat's ovum between the epiblast and hypoblast. This membranous follicle he named *membrana limitans hypoblastica*. The fact o[illegible] presence favours the view accordin[illegible] which the mesoblast is derived fro[illegible] epiblast. See Pro. Roy. Soc., vol x[illegible] plate 10.

is groove is laid the foundation and commencement of the cerebro-inal axis, which, as we have seen, is the supreme and dominating gan when that body has attained maturity, and which is thus formed om inflected epiblast. The groove becomes enlarged at its anterior d, in the situation of the future brain (Fig. 145, C), while the teral margins of the whole groove grow up (as the dorsal plates or

Fig. 144.—Diagram of Section through the Germ Area of a Mammal at Right Angles to the surface.

e. Epiblast.
i. Hypoblast.
m. Mesoblast, or third layer.
k. Cavity of the vesicle.

minæ dorsales) bend over and ultimately meet together above, us changing the groove into an elongated, hollow cylinder; the ntral cavity of which is the precursor of the canalis centralis, of e spinal cord, and of the third and fourth ventricles of the cerebro-

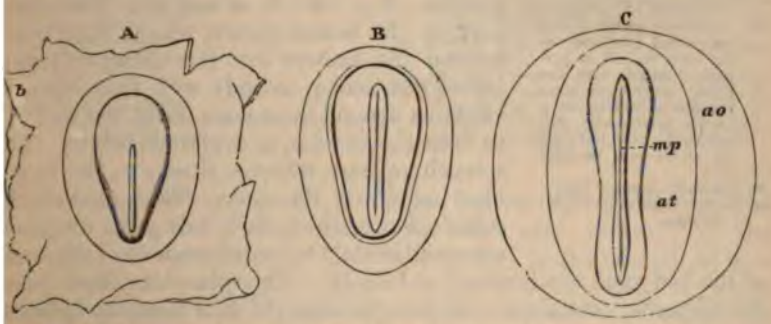


Fig. 145.—First appearance of the Embryo, as shown by the Medullary Groove.

A the germinal area is pyriform, and the primitive groove occupies two-thirds of the narrow hinder end.
B the groove is elongated, and the middle line and line closely surrounding it indicates the rising up of the laminæ dorsales or medullary plates on each side of it.
In C the embryo is seen somewhat expanded towards each end.
at. Transparent area.
ao. Opaque area.
mp. Medullary groove.

inal axis as well as of the *iter* between them—the enlargement at e cephalic end assuming the form of three successive dilatations or esicles. Beneath the longitudinal groove a cellular rod becomes eveloped, extending forwards as far as the hinder end of the front phalic vesicle and backwards to the end of the medullary groove. his rod is the NOTOCHORD, or CHORDA DORSALIS, and occupies the lace of the future bodies of the vertebræ, the soft substance of the ntervertebral discs of the adult being its persistent remnant.

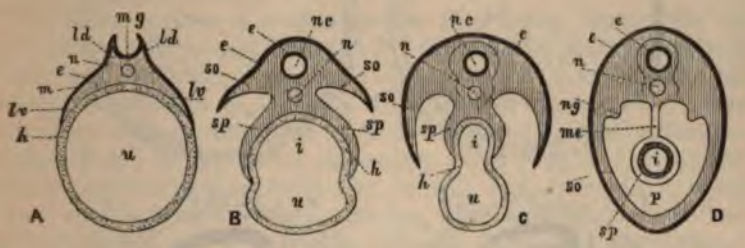
The notochord appears to be formed from the mesoblast, but it may be really of hypoblastic origin. While these changes are in progress, a depression appears close to both the cranial and caudal ends of the embryo—the head and *tail folds*—and these extending along each side of the embryo, the latter comes to look somewhat like a small boat, keel upwards, upon the surface of the ovum, surrounded by the groove or depression thus formed. The parts of this surrounding groove between the head and tail folds are called the *lateral folds*. At the outer margin of this depression the surface begins to grow up all round the embryo as a prominent circumvallation. Meanwhile the mesoblast extends outwards and downwards on each side of the embryo, so forming what are called the *ventral plates* and *laminæ ventrales* (Fig. 147, A, *lv*). As each ventral plate descends it splits into two secondary laminæ (one external, the other internal) called respectively the SOMATOPLEURE and SPLANCHNOPLEURE (Fig. 147, B, *so* and *sp*). The distal part of the somatopleure, where it extends beyond the embryo into the circumvallation before mentioned, ascends with that circumvallation around the groove about the embryo to form the amnion, as explained below. The splanchnopleure adheres closely to the hypoblast adjoining the yelk. That part of the somatopleure which does not grow upward comes ultimately to form the whole of the walls of the body and the limbs (Fig. 147, D). The splanchnopleure forms the alimentary canal and structures adjacent to it. The cavity between the somatopleure and splanchnopleure is the precursor of the future peritoneal cavity (Fig. 147, D, *p*), and the innermost layer of the former and the outermost layer of the latter form respectively the parietal and the visceral layers of the peritoneum. Thus we have the body cavity formed by a spontaneous longitudinal splitting of the mesoblast on each side. The further extension of the somatopleure gives rise to the AMNION. It is formed thus: the somatopleure of the mesoblast, carrying the epiblast with it, rises up on all sides of the embryo at the outer margins of the groove round the embryo (around the head, tail, and lateral folds in the circumvallation before mentioned) and as each ascending part is double, an extension of the primitive peritoneal cavity becomes thus continued upwards on all sides of the embryo. A chamber is at the same time thus gradually formed between the outer surface of the embryo and the innermost (more and more bent over) surface of this ascending, circumferential double layer, which thus gradually

Fig. 146.—EMBRYO MORE ADVANCED, SEEN SIMILARLY ABOVE WITH PART OF THE BLASTODERM ATTACHED.

The medullary groove is not yet closed over, but at the head end it is partially divided into the three central vesicles; the hinder end shows a smaller enlargement. Six primordial vertebræ (*pv*) are to be seen on each side.

so. Epiblast, or upper layer.
sp. Lower layer of the blastoderm.

grows up around and over the embryo. This up-growth continues until the ascending folds of the circumvallation meet and coalesce above the embryo, and so form a completely closed sac above it. This sac is the amnion (Fig. 148, [2], [3], [4]). The cavity enclosed by it is, of course, the same as the cavity of the "chamber" above



INITIAL STAGES OF DEVELOPMENT.

Fig. 147.—EMBRYO SEEN IN TRANSVERSE SECTION, SHOWING FORMATION OF SOMATOPLEURE AND SPLANCHNOPLEURE, AND OF THE PERITONEAL CAVITY. THE PART OF THE SOMATOPLEURE WHICH ASCENDS BEYOND THE EMBRYO IS NOT REPRESENTED.

mg. Medullary groove.
c. Epiblast.
m. Mesoblast.
h. Hypoblast.
ld. Laminæ dorsales.
lv. Laminæ ventrales.
n. Notochord.
nc. Neural canal.
sp. Splanchnopleure.
so. Somatopleure.
i. Intestine.
u. Umbilical vesicle.
ug. Prominences in which primitive urinary and sexual glands arise.
p. Peritoneal cavity.
me. Mesentery.
A. Embryo, with the mesoblast as yet unspl
B. Mesoblast split into somatopleure and splanchnopleure, and with an incipient separation between the intestine and th subjacent umbilical vesical.
C. Further closing off of intestine from umbilical vesicle.
D. The body cavity (or peritoneal cavity) completely enclosed by somatopleure, while the part of the splanchnopleure between th intestine and superior part of the embryo has become attenuated into a mesentery (*m*

mentioned as being "gradually formed between the surface of the embryo" and the "more and more bent over surface" of the ascending circumvallation. The embryo lies in the amnion as in a water-bed. For though at first this sac is very small, it subsequently enlarges and becomes filled with a certain fluid called the *liquor amnii*. As the ascending folds are (as before said) double on all sides (Fig. 148, [3]) it follows that upon their coalescence a double sac is at first formed. The amnion is the inner of these two sacs. The sac external to it (formed of the outer layers of all the folds) disappears by coalescing with the *chorion*, or outer envelope of the ovum, within which of course all the changes here described take place (Fig. 148, [4]). As the primitive peritoneal cavity was continuous with the space enclosed between the two layers of the ascending folds, it follows that (upon the completion of the amnion) there comes to be for a time a communication (over the back of the embryo and above the amnion) between the two sides of the peritoneal cavity. This space is occupied by a more or less fluid or gelatinous substance (Fig. 148, 5*r*). This communication is, however, soon cut off by the descent and in growth of that part of the somatopleure which forms the side-walls of the body of the embryo.

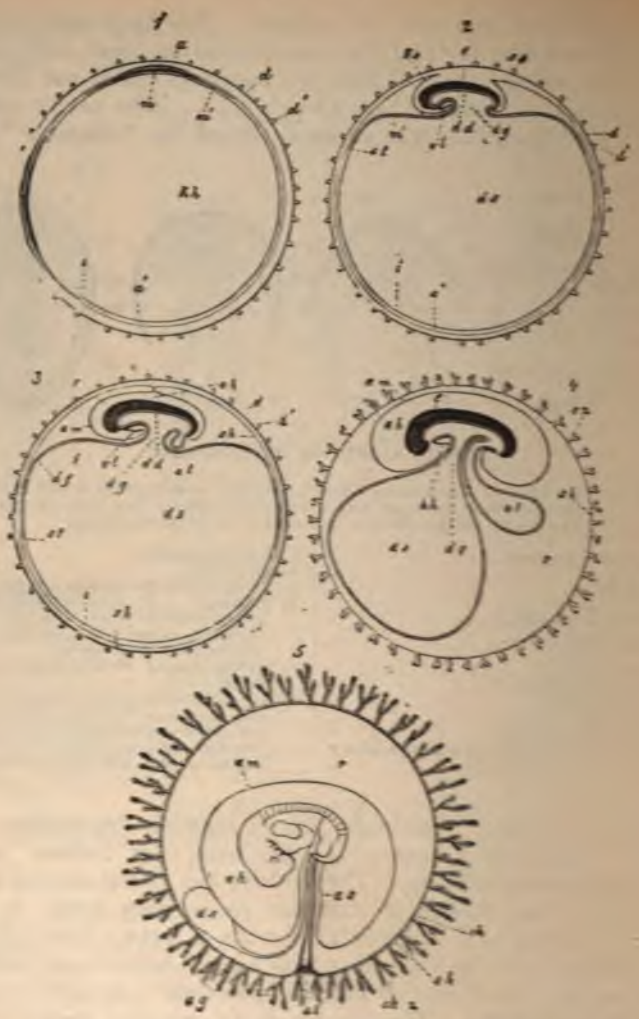


Fig. 148.—Five Diagrammatic Vertical Sections through the Long Axis of a Mammalian Ovum, to show the formation of its egg-membranes.

In Figs. 1—4 the section passes through the middle of the embryo. In Fig. 5, it passes a little on one side, so that the left side of the embryo can be seen.

1. Ovum in which the chorion has begun to be formed, with the blastoderm (and rudiment of the embryo) within it. The whole germ-vesicle consists of epiblast and hypoblast, in the germ area, mesoblast (m) has also appeared.
2. Ovum in which the head and tail-folds have contracted the umbilical aperture towards the yelk-sac; while the ascending circumvallation is seen rising at either end to form the amnion. Here, then, the embryo is beginning to separate from the germ-vesicle (ds).
3. The amniotic folds being completed, have met in the dorsal region; the umbilical opening is more contracted, and the allantois (al) has begun to sprout. Here we see the double sac forming above the embryo, the inner part of which alone becomes the amnion. The intestinal canal (ds) is beginning to be distinctly formed.
4. Here the inner amniotic sac or true amnion is detached from the outer or false amnion, which has disappeared by coalescence with the inner surface of the chorion. The cavity of the amnion is more distended, and the yelk-sac (ds) has become smaller and pedunculated. The allantois (al) projects into the space between the amnion, chorion and yelk-sac; and the villi are larger, and have begun to ramify.

Meantime, during the development of the amnion, another structure, of great importance to the embryo, is being formed. This is the ALLANTOIS (Fig. 148, 3 & 4, *al*), which buds forth from the mesoblast beneath the hinder portion of the incipient abdomen. It soon attains a large size, and becomes supplied with blood-vessels for a purpose to be presently described.

While the amnion and allantois are thus being formed, the side walls of the embryo are closing in by the median junction ventrally of the somatopleure of one side with that of the other side, and the splanchnopleure of one side with that of the other side, thus enclosing—between the inner layer of conjoined splanchnopleures—a space which is the future alimentary canal (Fig. 147, C and D). This is at first closed in front and behind, and everywhere, except at one ventral point, where it remains open, and in connexion with the remains of the yelk, which, with its enveloping membrane, is termed the umbilical vesicle (Fig. 147, C, *u*).

On each side of the medullary groove and notochord a series of quadrate thickenings appear, termed *protovertebræ* (Fig. 146, *pv*), which are the first signs not only of the vertebræ, but also of the muscles and nerves connected with them, to all of which they give rise. Inflections of the epiblast about the incipient head, lay the foundations of the organs of special sense, while an epiblastic inflection at each end of the alimentary tube forms respectively the buccal and anal chambers. In the mesoderm, immediately beneath the anterior end of the chorda, the blood and blood-vessels become developed, and one vessel, tubular and rythmically contractile, lays the foundation of the heart. Blood-vessels at first go to and fro between the umbilical vesicle and the heart to absorb nutriment from the yelk, but subsequently these are outstripped in development, and so replaced by other vessels which go to and fro between the allantois and the heart. Thus the great blood-vessels have at first a very different course and arrangement from that which they ultimately attain. About the alimentary canal, the liver arises, while the trachea

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5. More advanced embryo, showing the protovertebræ, visceral arches, and rudimentary limbs. The allantois has grown out to the inside of the chorion, and conveyed vessels to it. The villi are more complex. The umbilical vesicle is small, and connected with the embryo by a long duct. In the embryo cat, however, this vesicle is spindle-shaped, and of considerable size, and the duct is short.

e. Embryo.
a. Epiblast.
m. Mesoblast
i. Hypoblast.
am. Amnion.
hs. Head-fold.
ts. Tail-fold.
ah. Cavity of amnion.
as. Amnionic sheath of the umbilical cord.
kh (Fig. 1). Hollow of the germ-vesicle, which becomes (*ds*) that of the yelk-sac.
dg. Duct leading from the alimentary canal to the yelk-sac.
df (Fig. 3). Lining of umbilical vesicle or yelk-sac.
dd. Dorsal wall of intestine.
d. Yelk or vitelline membrane, or primitive chorion.
ch. Permanent chorion, with which not only the outer layer of the amnionic folds (*sh*), but also the allantois, has combined.
al. Allantois.
v. Space, filled with fluid, between the amnion and chorion.
hh. Region of the heart and pericardial cavity.
vl. Wall of the thorax in the region of the heart.
d' (Figs. 1, 2, and 3); *sz* (Fig. 4) and *ch x* (Fig. 5). Villi of chorion.
sh (Fig. 3). Outer layer of amniotic fold, which, in Fig. 4, has coalesced with the inner wall of the primitive chorion.

and lungs grow out from that canal ventrally. The renal and sexual organs arise close to the bifurcation of the ventral laminæ into the somatopleures and splanchnopleures, and the limbs bud forth as rounded processes, the distal ends of which subsequently grow out into digits, while the limbs themselves become flexed in reverse directions. On each side of the body, close behind the head, certain apertures appear, which lead from the exterior to what becomes the pharynx. These openings are the *visceral clefts*, and their interspaces are the *visceral* arches. Almost all the clefts disappear before birth. The formation of these various organs will be detailed subsequently, but their relations to the three primary layers, from which the whole of them are built up, may be summarized as follows. The epiblast gives rise to the epidermis of the skin, the nervous centres, and the organs of sense. The hypoblast forms the epithelium of the alimentary canal, except its two ends, and of the glands which open into it. The mesoblast forms the internal skeleton, the muscles, connective tissue, peritoneum and pleuræ, and the vascular and secreting organs generally. It forms, therefore, the great bulk of the cat's body.

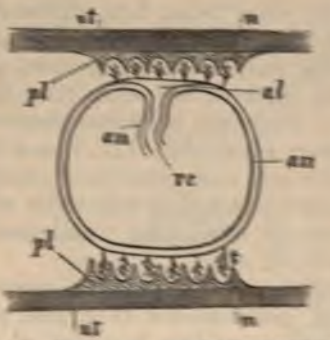


Fig. 148.—Section through Chest of Uterus, showing the two points of attachment of the Zonary Placenta, the Embryo being removed.

pl. Placenta.
m. Its maternal portion sending processes between.
. Tufts projecting from chorion or membrane, enveloping embryo.
vc. The umbilical cord.
am. Amnion.
uf, uf. Walls of the uterus.

§ 6. During the whole process of development the germ is nourished by absorption. Within the Graafian follicle it profits by the cells of the *discus proligerus* and *membrana granulosa*, and when cast forth from its follicle into the cavity of the uterus it absorbs nutriment from the secretions of the uterine walls by processes, or villi, which grow forth on all sides from the surface of its chorion. It also feeds upon the contents of the umbilical vesicle, absorbing nutriment thence by the help of the vessels which there circulate, and which are at first of great relative size and importance. With the development of the allantois, however, a new condition obtains. That organ is destined to convey out embryonic blood-vessels to the surface of the ovum, so that they may there be placed in intimate relation with the blood-vessels of a special, corresponding maternal structure, which is formed in the wall of the uterus around the circumference of the therein-contained ovum.

While the ovum is undergoing the incipient stages of development, corresponding changes take place in the maternal structures. The presence of the impregnated ovum within the uterus is accompanied by the growth, on the inner surface of that organ, of a

soft tissue called the *decidua*, within which the young ovum imbeds itself, and from which it at first derives its nutriment.

As the ovum grows, however, one portion of the decidua thickens and becomes highly vascular. This is called the *decidua serotina* (Fig. 149, *m*), and it forms a ring round that part of the uterine cornu in which the ovum lies. The adjacent part of the rapidly-enlarging ovum also becomes specially supplied with blood-vessels from the embryo contained within it, through the intervention of its already-mentioned allantois. Processes from the vascular ring of the chorion (Fig. 147, *t*) pass into recesses in the vascular ring of the uterus—the serotina decidua, and the two parts form an inseparable interlacement called the PLACENTA (Fig. 147, *pl*). The maternal and embryonic blood-vessels, however, nowhere actually communicate, and therefore no intermixture takes place between the blood of the embryo and the blood of the mother. An abundant gaseous interchange, however, is effected between them, the blood of the embryo taking oxygen from, and giving off carbonic acid gas into, the maternal blood. Thus the placenta is a temporary and indirect breathing organ for the embryo, which can breathe in no other way, lying, as it does, enclosed in fluid.

As has been already said, the allantois, with its blood-vessels—called *umbilical arteries and veins*—stretches itself forth into and across the space within the ovum, till it arrives at the inner surface of the chorion, where it expands, wrapping round the whole embryo with its amnion, carrying its vessels to the vascular portion of the chorion, and so contributing to form the placenta. The junction once effected, the arteries and veins connecting the fœtus with this part of the chorion rapidly enlarge. The umbilical arteries convey the impure blood of the fœtus to the placenta, where it is purified, as before said, and nourished by the influence of the maternal blood (the two fluids having but thin membrane between them), and is then returned to the embryo by the umbilical veins, which proceed back along the allantois from the placenta. Meantime, while the embryo is thus enclosed in its amnion and nourished by its allantois, the splanchnopleure grows in on all sides in the way before mentioned, so as almost to separate the embryo from the remnant of the yelk in its sac—the umbilical vesicle. The stalk which connects this vesicle with the intestinal cavity of the embryo is short but slender. It is called the *vitelline duct* or *ductus omphalo-entericus*. The umbilical vesicle remains of rather large size as a transversely-elongated sac produced into two horn-like prolongations. It lies between the amnion and the allantois.

The structure which connects the embryo or *fœtus* with the placenta is called the *umbilical cord*. This is made up mainly of the narrow part of the allantois (consisting of the embryonic or fœtal arteries and veins with connective tissue) with the vitelline duct, the whole being bound round and enclosed by a fold of the amnion extending down round it, and being thence reflected over the fœtus (Fig. 147, *vc*). The umbilical cord is the sole channel

through which nourished and oxygenated blood is conveyed to the fœtus, and its importance continues till birth. The establishment of pulmonary respiration, however, and the acquisition of the power of taking nourishment by suction, do away with all need for the placenta, and, by consequence, for its stalk, the umbilical cord, which is gnawed across by the mother on the kitten's birth. The

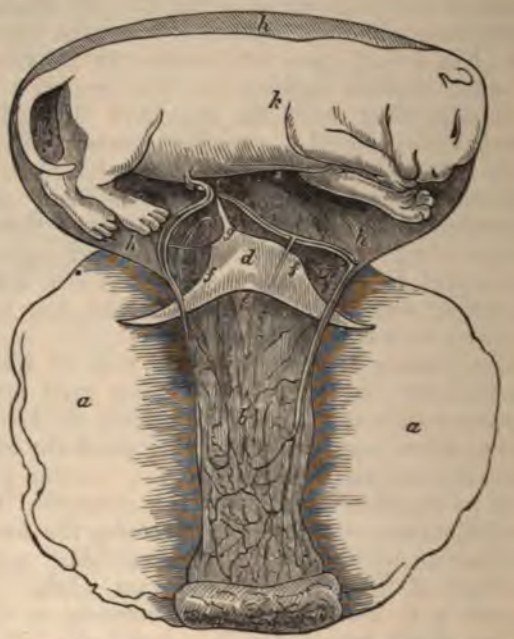


Fig. 150.—Fœtus in utero (Buffon and Daubenton), showing the Fœtus enveloped in Amnion, and with its zonary Placenta and spindle-shaped Umbilical Vesicle.

a. Chorion.
b. The zonary placenta.
d. Umbilical vesicle.
f, f. Its elongated extremities.
g. The vitelline duct.
h. The sac of the amnion
k. The fœtus.
The short umbilical cord is shown passing fr
the abdomen of the embryo to the placen
and immediately giving forth its vesse
forwards and backwards, into the placent

part left in connexion with the abdominal wall soon shrivels up, dries, and falls off, but a permanent mark of its place of attachment persists throughout life as the umbilicus or navel.

Such being the form and arrangement of the fœtal membranes and adjuncts, the embryo or FŒTUS itself gradually and in a round-about way assumes the image of the kitten in the mode already intimated, and which will be more fully explained in describing the development of the several organs.

The period of gestation is fifty-five or fifty-six days. The ovum having by that time attained its full inter-uterine development, vigorous contractions of the muscular walls of the uterus ensue, while the os uteri dilates. The embryo is thus expelled from the

terine cavity, and comes away, bringing with it a portion of the maternal part of the placenta, together with the fœtal part, with which the maternal part is inextricably united. Thus the superficial part of the decidua serotina comes away, while its deeper part is left, with a torn and bleeding surface. Coincidently with the termination of gestation, the mammary glands take on functional activity and become ready to play their part in the post-natal development of the young. After the expulsion of the embryos, of which several are in general simultaneously developed, the uterus forms a fresh internal lining, while the thickness of its walls decreases by degeneration and absorption of a portion of its muscular tissue, which had so much increased in quantity during pregnancy.

§ **7.** It remains to consider seriatim, the development of the various TISSUES and ORGANS of the body.

All the various tissues and structures of the adult cat (connective tissue, cartilage, bone—all parts of the skeleton of course included) arise from the primitive fluid, granule, and cells of the fertilized ovum by a process which is called *differentiation*. This term, which is often used as if it were a real explanation, simply denotes the fact that the various parts arise not through external actions, which are but the concomitants and conditions of their origin, but by an as yet utterly inexplicable and innate power possessed by the primitive substance or *matrix*, within which the parts referred to, come under the requisite external conditions) gradually to manifest themselves. Other terms relating to development similarly denote spontaneous and mysterious actions of the formative power, and are but convenient phrases for denoting the actions of such power, and not explanations of it.

Such terms, for example, are *segmentation*—which denotes that a structure, primitively of one piece, spontaneously divides its substance into parts; *vacuolation*—denoting the spontaneous resolution of part of a more or less dense structure in such a way as to give rise to a cavity or cavities within it; and *fenestration*—denoting that a solid structure has dissolved itself at one spot or more, so as to give rise to an aperture perforating it. When then the development of the tissues and parts of the body are herein described, the intention is but to state the order and mode in which they manifest themselves, the fact being distinctly recognized that an innate force is the real and efficient cause.

The primitive almost fluid substance containing granules, which exists in the developing ovum, is known as *protoplasm*; and protoplasm is often spoken of as if it were a sort of primary organic material —a distinct kind of formed substance—from which all organisms arise. But the fact that the primitive substance of one animal or plant is not to be distinguished by any chemical or physical test we can apply from the primitive substance of another animal or plant, does not by any means prove that the two are really the same substance. It does not prove this identity, because of the very different results which are successively evolved in the two cases, as development proceeds.

This ultimate diversity is amply sufficient to show that a real difference existed from the first—a difference thus demonstrable to our reason, though not manifest to our senses.

From the primitive substance of which the cat's ovum consists, all the ultimate constituent parts of its body are derived through the help of the *cell formations*, already described as the epiblast, hypoblast and mesoblast. It has already been mentioned that the epiblast gives rise to the epidermis of the skin and to the nervous centres; the hypoblast, to the alimentary epithelium; and the mesoblast, to the great mass of the body. But parts which are derived from one of these sources may acquire characters quite like those derived from another. Thus the linings of the two ends of the alimentary canal are (as has been said) formed from inflected epiblast, and epithelial structures (as in the lining of the vessels and of the peritoneal cavity) can be formed as well from the mesoblast as from the epiblast.

All the tissues and organs of the cat's body are then derived from cells, and indeed they are doubly so derived, since the ovum before yelk segmentation begins, is a perfect *cell*—with its *cell-wall* (or *periplast*) and its *nucleus* (or *endoplast*), the latter being furnished with one or more *nucleoli*. Thus this cell begets the cells of the three layers of the embryo, and these latter cells beget all the tissues and organs which subsequently arise, and the great mass of them are begotten by the cells of the mesoblast.

But though all the tissues have this ultimate cellular parentage, they by no means always retain a plainly cellular structure, as they severally arise from the primitive, or "*indifferent*," tissue of the mesoblast, and become definite connective, muscular or nervous substance, as the case may be. Sometimes they take on the form simply of a soft substance of one or another kind, within which nuclei are embedded at intervals. From analogy we may regard the parts of such substance which are adjacent to such nuclei as representing cells, the limits of which are severally indistinguishable.

The five main constituents of the cat's body—(1) connective tissue, with its derivatives, cartilage and bone; (2) epithelial tissue; (3) blood; (4) muscular tissue; and (5) nervous tissue—arise as follows:

Connective tissue appears to arise in the embryo, partly as a jelly-like substance, or matrix, and partly as cells from the mesoblast, which though more or less separated by this substance, yet remain connected by processes which grow out in a radiating manner from them. The fibres of the tissue are by some observers described as arising within the protoplasm of the cells, those of adjacent cells uniting, while the parts of the cell not thus transformed persist as connective-tissue corpuscles. Other observers, however, believe that the fibres arise, as an independent deposit, within the intercellular substance.

Elastic tissue is said to be formed from other cells which grow out and branch, becoming connected with processes from neighbouring cells.

Cartilage appears in its simplest condition (in the *chorda dorsalis* or *notochord*) as a mass of closely applied, thin-walled cells. The layer of the embryo from which these are derived, is (as has been

said) not yet positively ascertained, but the other cartilages of the body are undoubtedly of mesoblastic origin. The walls of the primitive cartilage cells thicken and form the intercellular matrix, acquiring at the same time the special qualities of cartilaginous tissue. The thus-formed matrix may remain clear and structureless, or may become fibrillated, as in the case of fibro-cartilage.

Bone is a substance which is never directly formed from the indifferent embryonic tissue, but requires for its development the pre-existence of either cartilage or connective tissue. The process of its formation in these substances has been already noticed.*

Epithelial tissue is the most distinctly and permanently cellular of all the tissues of the body, and it arises directly from the cells of the epiblast and hypoblast, with the exception of the endothelium of the vessels and pleuro-peritoneal cavity, and some other parts which are derived (as already said) from the mesoblast. The ependyma of the cerebral ventricles is the persistent epiblast of the lining of the medullary groove of the embryo. Ova and spermatozoa may be considered as special modifications of epithelial tissue.

Blood appears to originate within cells derived from the mesoblast,† either by a multiplication of their nuclei and the acquisition of a red colour by the protoplasm around each nucleus, or else as a sort of deposit within the cells. However originating, the primitive corpuscles when formed become separated from one another by a process of vacuolation‡ within the cells. The cells then enlarge and send out processes which unite with those of other cells. The walls which separate the cavities of such united processes then disappear, so that their cavities communicate, and thus blood and blood-vessels are simultaneously formed.

The primitive red corpuscles are nucleated, and larger than those which subsequently arise, which latter, together with the white corpuscles, seem to be formed mainly by the spleen, the nucleated red corpuscles disappearing and being replaced by the smaller, flattened non-nucleated corpuscles, during embryonic life.

Muscular tissue, though by no means clearly cellular in its fully formed condition, is said to have a distinctly cellular origin, being formed by direct transformation of embryonic cells as follows: § the cells elongate and acquire an investing membrane and often pointed ends. The nuclei multiply, and the contained protoplasm of the cells gradually acquires its striated character. The investing membrane becomes the sarcolemma, and the scattered nuclei become the corpuscles. The unstriped muscular fibres originate simply by the lengthening out and flattening of cells, which acquire pointed ends and an elongated nucleus.

Nervous tissue is, as has been said, mainly derived from the epi-

* See *ante*, p. 20.

† A perfect agreement has not yet been arrived at as regards their mode of origin. See Balfour, Quarterly Journal of Microscopic Science, July, 1873 and Schäfer's Proceedings of the Royal Society, 1874.

‡ See *ante*, p. 329.

§ See Wilson Fox, Phil. Trans., 1866.

blast; but although the nervous centres are thus formed, and though the cranial nerves arise also as small invaginations of epiblast, yet the mass of nerves which permeate the body in all directions cannot be so derived, but must originate from mesoblastic tissue. The ganglionic cells or nerve corpuscles are doubtless derived from embryonic cells, which became transformed in nature and send forth processes (very generally) in the way described.*

As to the nerve-fibres, they seem to be formed by the coalescence

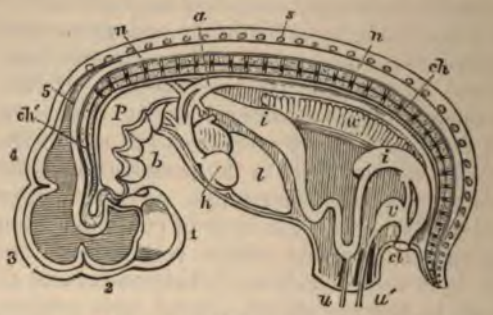


Fig. 151.—Longitudinal Section of an Embryo, showing the Incipient Vertebral Column with its Vertebral Centra and Spinous Processes.

1. Cerebral hemispheres.
2. Vesicle of the third ventricle.
3. Mid-brain.
4. Cerebellum.
5. Medulla oblongata.
ch. Notochord passing forwards through the bodies of the vertebræ into the basis cranii, and terminating in the head between the infundibulum and the pituitary body.
s. The spinous processes of the vertebræ.
n. The spinal cord.
P. The pharynx.
h. The heart.
l. The liver.
i. The stomach and intestine.
cl. The cloaca.
v. The urinary bladder and pedicle of the allantois.
u, u'. The umbilicus, or root of the umbilical cord, containing the duct from the intestine to the yelk-sac, the pedicle of the allantois (or urachus), and the umbilical vessels.
w. The Wolffian body, which appears as an elongated viscus, with many transverse lines situated above and between the two letters, *i* and *i*; whereof the left-hand *i* is placed upon the stomach, and the right-hand *i* on the large intestine close to the cæcum and entrance of the small intestine.

in linear series of spindle-shaped cells, and to be at first of the nature of pale or grey fibres, but afterwards, in great part, to acquire a medullary sheath and to become white fibres.

§ **8.** We may next consider the origin of the organs, and first the internal skeleton.

The AXIAL SKELETON makes its appearance much earlier than the appendicular skeleton, inasmuch as its foundations are laid in the laminæ dorsales bounding the medullary groove, and in the notochord as already described. The distinction of the axial skeleton into its vertebral and cranial portions is laid down from a very early period, since the enlargement of the anterior end of the medullary groove into the cerebral vesicles at once marks out the cranial part, a distinction rendered yet plainer by the non-extension of the chorda dorsalis forwards through it.

* See *ante*, p. 255.

The earliest indication of the segmented condition of the VERTEBRAL SKELETON is the appearance of the quadrate masses of tissue, appearing serially in pairs behind the head—the so-called *proto-vertebræ* (Fig. 146, *pv*), or *dorsal segments*, already noticed as arising in the mesoblast on each side of the chorda dorsalis and medullary groove. The front part of the first of these bodies corresponds in position with the atlas, and each pair of dorsal segments gives rise, amongst other structures, to part of the bony spine. The dorsal segments do not, however, correspond with the future vertebræ, but each segment becomes transformed into: (1) the hinder part of one vertebra, (2) the anterior part of the vertebra next behind, (3) the roots of a spinal nerve, and (4) the muscles and skin immediately connected with the vertebral parts so formed. Thus each primordial vertebra becomes ultimately segmented, while each successive pair of such primordial vertebræ ultimately coalesce, and so a different segmentation is brought about from that which appears at first; the points of separation of the later segmentation, alternating with those of the earlier segmentation. The first dorsal segment of each side differs from those which succeed, in that when it becomes segmented, its anterior half has nothing in front wherewith to coalesce, and thus the atlas must be formed from half a primordial vertebra instead of being formed, like the other vertebræ, from the hinder half of one primordial vertebra and the anterior half of the primordial vertebra next behind.

Moreover, while the upper part of each dorsal plate becomes a segment of dorsal muscle, with its skin, the lower part undergoes a different change in its anterior (cephalic) and posterior halves. Anteriorly it gives rise to the root and ganglion of a spinal nerve. Posteriorly it gives rise to the transverse process of a vertebra or proximal portion of a rib.

The inner part of each dorsal plate bifurcates as it extends inwards. One branch ascends in the dorsal lamina till it meets its fellow of the opposite side and so forms the foundation of the future neural arch. The other branch advances inwards above and below the chorda, and blends with its fellow of the opposite side to form the foundation of the central portion of a vertebral segment. Thus each permanent vertebra is the offspring of the parts of two adjacent primordial vertebræ. Its neural arch, transverse processes, the proximal part of its ribs, and the cephalic portion of its centrum, are formed from the hinder end of one proto-vertebra, while the rest of its centrum and its spinal nerves are formed from the anterior (cephalic) end of the proto-vertebra next behind.

This condition having been, as it were, laid down in soft tissue, transformations of parts of the structures thus formed, into *cartilage*, soon begin.

Cartilage of the ordinary kind first invades the body of each vertebra and surrounds the chorda, encroaching on and constricting it at intervals, the chorda yet continuing a structure of large thin-walled cells enclosed in a fibrous sheath. Cartilage becomes also

deposited at intervals along each dorsal lamina, forming cartilaginous neural arches which, however, do not for some time fully unite together on the dorsal side of the myelon. Cartilages also extend down in each ventral lamina as the cartilaginous predecessors of the ribs, and those of the thorax, by their median fusion in the mid-ventral line, lay the foundation of the sternum.

The third stage of vertebral development, or the *ossification* of the spinal column, begins to show itself as three (or four) ossific centres arising in each of the vertebræ. These centres are placed one in each lateral part (at the junction of the transverse process and neural arch), and the other, or third, in the centrum. This last is sometimes double at first.

Besides these separate centres each vertebra, while immature, has certain *epiphyses* or temporary separate terminal ossifications. Thus the tip of each prominent process (neural spines, transverse and articular processes and the metapophyses) has its epiphysis, and a thin lamina of bone is developed as an epiphysis on both the anterior and posterior surface of each centrum. The atlas ossifies from two lateral ossifications, and one median one ventrally placed.

Fig. 152.—Diagram of Fœtus, showing the Visceral Arches and Budding Limbs.

(It represents mainly conditions existing between the third and fourth weeks.)

a. Prominence produced by incipient cerebrum.
b. Prominence produced by region of third ventricle.
c. Prominence by region of corpora quadrigemina.
d. Prominence produced by cerebellum.
e. Prominence produced by medulla.
al. Allantois.
h. Heart.
l. Liver.
au. Incipient ear.
oc. Incipient eye.
na. Incipient nose.
ns. Naso-frontal process.
mps. Maxillary process (from first visceral arch) laying foundation of upper jaw.
1, 2, 3, 4. "Visceral arches;" between them are the "visceral clefts."

In the axis, in addition to the ordinary ossific centres found in other vertebræ, the odontoid process ossifies from two centres, placed side by side, which soon unite. There is also an epiphysis at the apex of the odontoid process, and one between it and the centrum of the axis as well as on the hinder surface of the latter. Thus the odontoid process ossifies as if it were, as in fact it is, the true centrum of the atlas vertebra.

The ribs are ossified each from one centre, with an epiphysis for the tuberculum and another for the capitulum.

In the cervical vertebra more or fewer of the transverse processes ossify, at least occasionally, from a distinct ossific centre in their ventral branch, a circumstance which tends to show (what is in fact the case,) that these double (or perforated) transverse processes are ribs with very short bodies.

Similarly the sacral vertebræ have each a distinct ossific centre in *each of* their lateral masses.

The manubrium ossifies after the other segments of the sternum, which seem each to ossify from one centre.

§ 9. The DEVELOPMENT OF THE SKULL takes place in a specially circuitous manner, so that its early stages are strikingly unlike its mature condition. The first indication of the future skull is given by the expansion, before mentioned, of the anterior end of the medullary groove, which expansion, as has been said, becomes divided by two lateral constrictions (one in front of the other, on each side) so that three rounded vesicles are formed lying serially one before the other. The notochord extends forwards to beneath the second of these vesicles, which bend down sharply in front of its anterior termination, so that there comes to be one vesicle above, one in front of, and one below the anterior termination of the chorda.

These vesicles are, as we shall hereafter see, the commencements of the future brain.

In the walls of the ascending laminæ dorsales, which bound the vesicles laterally, there are no quadrate thickenings like those developed on each side of the chorda in the vertebral region, while peculiar developments take place in their ventral laminæ. For while the medullary groove is being arched over and converted into the great axial, neural canal, by the ascending laminæ dorsales, another axial canal is being formed beneath the neural one by the descending lamina ventrales. This second axial canal is the rudimentary alimentary one. The ventral laminæ, as they bend down to enclose the incipient pharynx, grow thinner and thinner at successive intervals, one behind the other, till a series of perforations, the *visceral clefts*, are formed, one after the other, each cleft leading from the exterior into the pharyngeal cavity. Four such visceral clefts appear on each side. The perforation proceeds from within outwards, the hypoblast being absorbed first, then the inner part of the mesoblast, and finally, the whole of the mesoblast, the hypoblast growing outwards along each advancing wall of each aperture, and ultimately becoming continuous with the epiblast. In front of each cleft the wall of the ventral lamina becomes more or less thickened, forming what are called the *visceral arches* (Fig. 152, ^{1}, ^{2}, ^{3}, ^{4})—each such lateral series of arches being at first separate from their fellows of the opposite side, as are the ventral laminæ themselves. Meantime another pair of vesicles—the cerebral vesicles—grow forwards (side by side) from that which was at first the most anterior vesicle; and a pit formed beneath the outer anterior part of each cerebral vesicle lays the foundation of the future nasal organs (Fig. 152, *na*), while two other and more posterior invaginations on each side (one beneath what was the first vesicle and the other beside the hindmost) respectively lay the foundations of the eye and of the ear. The mouth is formed by a superficial depression—as will be subsequently more fully explained. On each side of the mouth the first visceral arch has meantime grown down and united distally with its fellow of

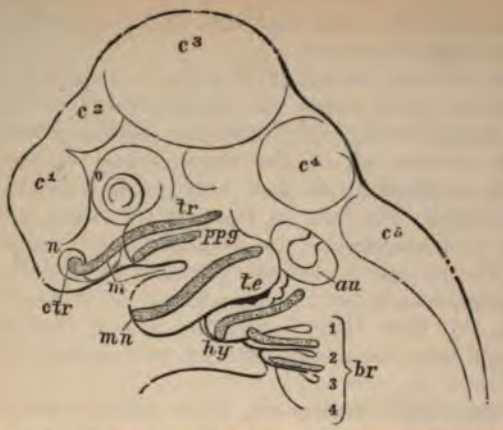


Fig 153.—Outline of the Head and Neck of an Embryo Pig, two-thirds of an inch in length, seen laterally Magnified seven diameters.

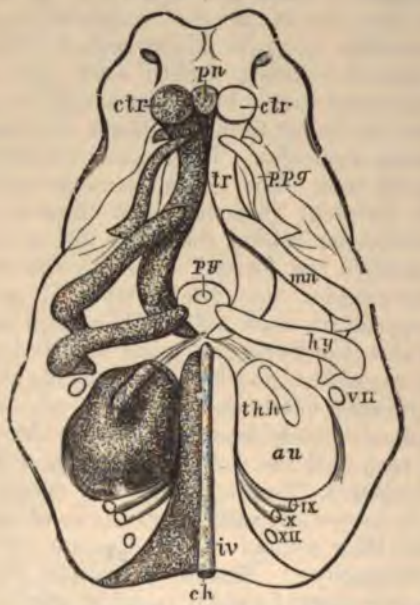


Fig. 154.—The Skull of the same Embryo (in its Incipient Stage of Development), seen from below. Magnified ten diameters (ventral aspect).

The following letters indicate the same parts in whichever of the above figures they occur, or in both figures :—

c^1 to c^5. The five divisions of the young brain.
a. The eye.
n. The nose.
m. The mouth.
tr. Cartilage of the trabeculæ.
ctr. Cornua trabecularum.
pn. Pre-nasal cartilage.
ppg. Pterygo-palatine cartilage.
mn. The mandibular arch, with Meckel's cartilage.
te First visceral cleft, which becomes the tympano-Eustachian passage.
au. The auditory vesicle.
hy. The cerato-hyoid arch.
br (1 to 4). The branchial bars and clefts.
thh. The thyro-hyoid.
py. The pituitary fossa.
ch. The notochord in the cranial basis, surrounded by the investing mass (*iv*).
VII. Facial nerve.
IX. Glosso-pharyngeal.
X. Pneumogastric.
XII. Hypo-glossal.

the opposite side to form the lower jaw, while a process grows forward and upward from the more proximal part of each first visceral arch, such growth, termed the maxillary process (Fig. 152, *mps*), laying the foundation of the upper jaw. The two maxillary processes do not, however, join together in front, but both join a median down growth, termed the *naso-frontal process* (Fig. 152, *ns*). This last-named process descends from the front end of the floor of the incipient cranium, and has on each side of it one of the two depressions which are the incipient olfactory sacs. Its lower end forms the middle of the front of the upper jaw, while the maxillary processes which unite with its distal end, on each side, form the sides of the upper jaw. The interval left on each side (above the junction of the naso-frontal and maxillary processes,) forms the nasal passage, and, in part, the lachrymal

canal. The first visceral cleft persists on each side as the external auditory meatus, the tympanum and Eustachian tube. The other visceral clefts all successively close up and disappear. The primitive roof of the mouth is formed by the floor of the cranial cavity; subsequently a lateral growth from each maxillary process extends inwards so as to form a partition across the upper part of the primitive buccal cavity, thus constituting the palate, and separating the hinder parts of the nasal passages from the mouth. The posterior nares open at first (before this growth of the palate) into quite the anterior part of the primitive buccal cavity.

The *cartilaginous* basis of the true future cranium is laid at the anterior end of the chorda dorsalis, which becomes surrounded by a solid, flattened mass of cartilage called the *basi-cranial plate* or *parachordal* cartilage, which is the precursor of the basilar part of the occipital bone.

Continuous with this on each side is a rounded portion of cartilage, which encloses the primitive ear (formed by a depression of the surface, as before mentioned) and is the precursor of the petrous part of the temporal bone (Fig. 154, *au*). The basi-cranial cartilage grows up on each side, and these lateral parts meet together above and enclose the foramen magnum with a cartilaginous ring. The basi-cranial plate, together with the enclosed chorda, stops short anteriorly at the hinder margin of what later becomes the sella turcica.

From the front of the basi-cranial plate two cartilaginous rods, called the *trabeculæ cranii* (Figs. 153 and 154, *tr*), extend forwards. They at first diverge, but afterwards converge and meet, thus enclosing between them the place of the future pituitary fossa (Fig. 154, *py*). The trabeculæ at their anterior junction form a cartilaginous expansion called the *ethmo-vomerine plate*, which sends downwards three other plates to form the median and lateral ethmoids (thus embracing the two primitive olfactory sacs,) ingrowths of the lateral ethmoids forming the future maxillo-turbinals. Also two small cartilages appear, on each side of the cranial cavity, as forerunners of the ali- and orbito-sphenoids.

The walls and roof of the skull are otherwise completed by membrane only, until the commencement of that membrane's ossification.

There are certain other cartilages, however, which play an important part in forming certain parts of the bony skull, namely, the cartilages of the visceral arches.

The first of these descending rods of cartilage, is connected above with the cartilaginous auditory capsule, and is called "Meckel's cartilage" (Figs. 153 and 154, *mn*). What has the appearance of being merely an outgrowth forwards from this first descending rod (the maxillary process of the first visceral arch) lays the cartilaginous foundation of the bony upper jaw, including the pterygoid and palatine bones (*pps*), while the rest of Meckel's cartilage (beyond the point where such process *is* given off forwards) lays the cartilaginous

oundation for the lower jaw, and ends by uniting with its fellow of the opposite side.

The next, or second cartilaginous rod (*hy*), connected above, like the first, with the auditory capsule, descends in the second visceral arch, and lays the foundation of the anterior cornu and body of the os hyoides.

The cartilage of the next visceral arch (Fig. 154, *th*) is the precursor of the posterior cornu of the os hyoides. No noticeable permanent part of the skeleton is formed in the fourth visceral arch.

§ 10. The process of OSSIFICATION of the skull begins with the mandible, where one centre of ossification appears in each lateral moiety at an earlier period than in any other part of the skeleton. It is an ossification in the membrane investing Meckel's cartilage, and not in the cartilage itself.

Immediately after the mandibular ossification, follows that of the maxillæ and premaxillæ.

The premaxillæ are ossifications in the cartilage of the naso-frontal process, while the maxillæ are ossifications in the membrane investing the maxillary processes. The *palatine* and *pterygoid* bones arise as ossifications in the cartilage of the maxillary process.

Fresh points of ossification also indicate the *supra-occipital*, the *parietals* and *interparietals*, the *frontals*, the *squamosals*, the *vomer*, the *nasals*, the *lachrymals*, and the *malars*, all these bones being ossified directly from membrane, and not through pre-existing cartilage; but cartilaginous ossifications also indicate the future *basi-* and *ex-occipitals*, the *ali-sphenoids*, the *basi-sphenoids*, and the *orbito-sphenoids*, with the *pre-sphenoid*, as also the *palatines* and *pterygoids*, as above mentioned. Other ossifications arise successively and at various intervals. Thus, the median ethmoid and cribriform plate ossify late, as also do the bones of the os hyoides. The vomer is an ossification of the membrane investing laterally the lowest part of the ethmo-vomerine cartilage.

The *occipital* bone for a time exists in four distinct pieces, the basi-, ex- and supra-occipitals.

The *frontal* bones remain divided from one another by a continuation forwards of the sagittal suture.

The *sphenoid* bone consists at an early period of eight distinct and significant parts: the bulk of the body, or basi-sphenoid; the front part of the body, or pre-sphenoid; the greater wings, or ali-sphenoids; the lesser wings, or orbito-sphenoids; and the true pterygoid bones.

The *temporal* bone arises from many distinct centres, and consists for a time of several distinct bones. Amongst these bones are the squamosal (including the squamous part and zygomatic process), the tympanic parts, and the tympano-hyal. The bone which forms the inner and larger chamber of the tympanic cavity does not appear till a fortnight after birth. It sends in a process to form the septum, as does also the outer tympanic bone, so that the septum in

the adult really consists of two layers of bone which have anchylosed together.

Besides these four elements, three other distinct ossifications arise in the primitive cartilaginous auditory capsule, spread and coalesce to form the petrous and mastoid portions of the temporal bone. They are distinguished by their various relations to different parts of the bony and membranous labyrinths. The first of these is called the *pro-otic*, and forms the upper rim of the *fenestra ovalis*, and invests the anterior vertical semicircular canal. It ultimately forms that part of the petrous bone visible inside the skull and part of the mastoid. The second ossification is the beginning of the *opisthotic*. It forms the lower rim of the fenestra ovalis, and entirely surrounds the fenestra rotunda. It constitutes the lower part of the petrous bone. The third ossification results in a bone called the *epiotic*, which invests the posterior vertical semicircular canal. It ultimately forms the mastoid process.

The *auditory ossicles* are formed, in part at least, by ossifications of the proximal ends of the cartilages of the first and second visceral arches.

That of the first arch, or Meckel's cartilage, long persists on the inner side of the mandibular ramus, but its upper end ossifies as the processus gracilis and body of the malleus. The proximal end of the second arch, which appears at one period to be bifurcated, has as ossifications of one of its upper ends, the tympano and stylo-hyals, while the other end becomes the body and long crus of the incus, the latter being its apex and summit.

The stapes is of a different nature, being a small part of the cranial wall which has grown out, become separated, and secondarily connected with the upper part of the second arch.

The lower end of this arch ossifies as the epi-, cerato- and basi-hyals.

The os orbiculare is the uppermost end of that part, the lower portion of which is the thyro-hyal.

The thyro-hyals are the solitary ossifications of the third viscera arch.

Thus, in *recapitulation*, the skull as a WHOLE may be said to arise as follows:—the cranial walls and floor behind, are formed from the parachordal and auditory capsular cartilages; in front, by the trabeculæ, the ethmovomerine plate, alæ and orbital cartilages; above, from membrane. The visceral arches form the jaws and hyoid, in conjunction with downgrowths from the ethmovomerine plate. The trabeculæ extend forwards between the floor of the brain cavity and the roof of the pharynx, closely embracing the pituitary fossa, into which the roof of the primitive buccal cavity temporarily (see below, p. 343) projects.

§ 11. The LIMBS of the embryo begin as two slight prominences on the surface of each lamina ventralis. They subsequently take the form of somewhat cylindrical processes, each with a flattened terminal expansion (Fig. 152). This expansion becomes divided at its distal end into five processes (*the digits*), the pre-axial one of which in

each limb diverges from the others to a certain extent. The hallux, however, does not continue to develope. At first each limb is so placed that its dorsal surface is outwards, and thus the concavities of both the elbow and knee are directed inwards. As development proceeds, the two limbs are both rotated, but in opposite directions. The fore-limb becomes so rotated that the extensor surface is turned backwards, while the pelvic limb is rotated so that the corresponding surface is turned forwards. Thus, the elbow and knee come to be bent in opposite directions. The pelvic limb requires no further torsion, since the foot is now ready to assume the posture needful for locomotion. The bent arm, however, would have the back of the fore-paw turned downwards if no further change took place—a posture manifestly inconsistent with the animal's mode of walking, which requires the palmar surface to be applied to the ground. This difficulty is obviated by a further torsion, but one which is confined to the forearm and paw. This further torsion consists in a change from the primitive condition of *supination* into that before described as *pronation*. With the exception of the clavicle, all the bones of the fore-limb are preformed in cartilage.

In the *scapula* the coracoid process shows a separate centre of ossification, and two such appear in the acromion process. The supra-spinous part of the scapula ossifies as a separate plate of bone, and is quite distinct from the rest at birth.

The *humerus* arises from one main ossification in the shaft, and two terminal epiphyses. The proximal epiphysis arises from three centres, one in the head and one in each tuberosity. The distal epiphysis arises from four centres, which respectively appear in the two condyles, the capitellum and the trochlea. Both the *radius* and the *ulna* ossify from one central ossification in the shaft, and two terminal epiphyses.

Ossification of the carpus begins later than does that of the metacarpus and digits; only one centre of ossification is formed in each carpal, except the scapho-lunar, which has two.

The first, or most pre-axial metacarpal (that of the pollex), has its epiphysis at its proximal end. The epiphysis of the other metacarpals is placed at the distal end of each. All the phalanges without exception have their epiphyses at their distal ends (Fig. 60).

The *ossification* of the *lower limb* begins soon after that of the upper, a bony nucleus appearing early in the shaft of the femur, and also in that of the tibia. Apart from the patella, all the bones of the pelvic limb ossify from cartilage.

The *os innominatum* arises from three centres—those of the ilium, ischium and pubis—with certain epiphyses, the principal of which are one on the tuberosity of the ischium and another along the crest of the ilium.

The *femur* (Fig. 6) has one epiphysis for its head, one for each trochanter and one for its distal end.

The *tibia* and *fibula* have each one principal ossification—that of the shaft—and two terminal epiphyses. In the tibia the superior

epiphysis is the first to appear and the last to unite. In the fibula the superior epiphysis is both the last to appear and also to unite.

The tarsals each ossify from one centre, as do the carpals, except the os calcis, which has also an epiphysis at the end of its tuberosity.

The *metatarsals* and *phalanges* of the hind-foot (or *pes*) ossify in the same way as do the corresponding parts of the fore-foot (or *manus*), except that the hallux remains in a very rudimentary condition. The bony parts of the hind-paw ossify at about the same time as do those of the fore-paw.

§ **12.** The MUSCLES of the trunk arise in what are called the "muscle-plates" of the primordial vertebræ, forming, as such plates do, the upper part of each dorsal segment. Hence are derived the erector spinæ mass of muscles, the segments of which primitively correspond in number and position with the vertebræ themselves. The muscles of the abdominal wall are formed in the mesoblast of the somatopleure. The sub-vertebral muscles, such as the longus colli, &c., are formed in the mesoblast, which lies nearer the centre than the division between the somatopleure and splanchnopleure ever extends. The muscles of the limbs do not arise as protrusions of the body muscles outwards. They are directly formed in the mesoblast of the budding members themselves.

§ **13.** The ALIMENTARY CANAL is formed, as has been already intimated, by the splanchnopleure and hypoblast. It is at first in the form of an axially directed groove placed beneath the notochord, and opens downwards towards the yelk—and therefore is turned in the opposite direction to the medullary groove above it. The walls of the groove are, on each side and in front and behind, formed by mesoblast, everywhere lined by the hypoblast. This groove soon changes (by the descent and convergence of the splanchnopleure on both sides of it) into a canal. At each end (*i.e.*, at the head and tail end) of this canal, the descending ventral laminæ (which are there undifferentiated into somatopleure and splanchnopleure), close it in; so that, as has been already said, the incipient alimentary canal at first ends blindly both in front and behind, though in its middle it remains open, communicating with the yelk or vitelline sac by means of the vitelline duct. When the communication is almost closed up, the vitelline sac takes the name of the umbilical vesicle, and on it ramify certain blood-vessels, which are, for a time, of great importance.

The incipient alimentary canal is straight, cylindrical and attached to the underside of the vertebral column by a wide but thin layer of mesoblast. After a time the tube, towards the middle of the body, bends down away from the vertebral column, pulling out, as it were, the interposed layer of mesoblast into a thin vertically extended membrane, the future mesentery. Part of the tube on the anterior (cephalic) side of this loop or curve, dilates more and more and becomes the stomach; the part on the posterior side of the loop becomes the transverse colon. To the most prominent and middle part of the loop itself, the pedicle of the umbilical vesicle is attached. In

subsequent development, the part of the loop pre-axial to this point of attachment, increases in length vastly more than does the part post-axial to it. The part in front (pre-axial) becomes the duodenum, jejunum, and the greater part of the ileum. The part behind

Fig. 155.—Longitudinal Vertical Section through an Embryo, showing the incipient Intestine with the relations to it of the Lungs and Liver.

d. Intestine.
o. Mouth.
a. Anus.
l. Lungs.
h. Liver.
g. Mesentery.
v. Auricle of heart.
k. Ventricle of heart.
b. Arterial arches.
t. Aorta.
c. Yelk-sac.
m. Duct leading from the intestine to the yelk-sac.
u. Allantois.
r. Stalk of allantois.
n. Amnion.
w. Cavity of amnion.
s. Outer layer of primitive amniotic fold, which is separating off to coalesce with the inside of the primitive chorion.

(post-axial to) the attachment of the umbilical vesicle, becomes the rest of the ileum and the colon. Thus that proximity of the transverse colon to the stomach and duodenum which we have seen in the adult condition, is initiated at first; the long intervening tract being formed by the outgrowth and coiling of the primitive loop, the distal ends of which (stomach and transverse colon) preserve very nearly their primitive relations. The distinction between the large and small intestine is first indicated by a small prominence, the future *cæcum*, which appears a little post-axial to the attachment of the vitelline duct of the umbilical vesicle. The large intestine is, at first, of less capacity than the small.

The formation of what are ultimately the two ends of the alimentary canal, namely the mouth and anus, has already been incidentally referred to. The primitive pre-axial end of the alimentary canal reaches beneath the skull, where it ends blindly below the pituitary space and forms the œsophagus and pharynx.

The anterior end of the canal is at first closed by the lamina ventralis, which descends in front of it as a single plate, not divided *into* an outer somatopleure and an inner splanchnopleure. In the

external surface of the pre-axial end of the embryo, the *mouth* appears as a depression on the surface of the front end of the head. This depression is bounded above by the naso-frontal process and below by the first visceral arch, and the tongue arises in the floor of the chamber thus formed. This primitive buccal cavity extends back beneath the cerebral vesicles till it meets the blind end of the front of the pharynx, into which it soon opens by a process of absorption of the intervening partition formed by the just mentioned lamina ventralis, part of which partition persists as the velum palati. An upgrowth from the buccal cavity, the pituitary body, meets a downgrowth (between the trabeculæ) of the brain—the infundibulum. It is thus these parts are formed. Afterwards the pituitary body becomes cut off from the buccal cavity and adheres to the infundibulum.

The *anus* is formed in an analogous manner at the post-axial end of the embryo. Here at first the intestinal groove is continuous with the medullary groove round the hind end of the chorda dorsalis, but the ventral lamina descends behind, as a single plate not divided into an outer somatopleure and an inner splanchnopleure, and closes in the hinder end of the alimentary tube. The hindermost part of this primitive tube is called the *cloaca*. Beneath the posterior end of the chorda a depression of the epiblast appears; this deepens, and the mesoblast of the ventral lamina is absorbed, a perforation being effected and the rectum and anus thus formed. It is from the ventral wall of the cloaca that the allantoic sac before described grows out, but it grows out beyond the point where the ventral lamina begins to be differentiated into somatopleure and splanchnopleure. It grows out therefore from the latter into the interspace dividing those lamellar subdivisions of the mesoblast.

The *teeth* are *developed* each by a double process. In the place for each tooth that is to be, a depression takes place in the mucous membrane of the gum, the deepest layer of the epithelium thickening and extending into such depression. The sac of epithelium thus formed widens at its deepest part, while simultaneously a papilla of the mucous membrane rises up from below and pushes itself into the deep surface of the widened part of such epithelial sac. The mucous papilla ultimately becomes the mass of the future tooth, while the deepest surface of the epithelial inflection (into which the ascending papilla has protruded) becomes the enamel of the tooth, on which account it is called the "*enamel organ*." Thus each tooth arises from two distinct sources. In the process described, the neck of the epithelial depression becomes exceedingly attenuated, while what is called a "dental sac" forms itself about the developing tooth by direct transformation of the mucous membrane, into an outer layer of fibrous tissue with a vascular layer within. The contained papilla then assumes the shape of the crown of the future tooth, and soon begins to calcify, thin caps of dentine being formed on the milk teeth within the gum, at an early period during gestation, each cap thickening by degrees as it extends its margins. As soon

as the crown of the tooth is completed its base becomes constricted, and then, as it grows, the papilla becomes narrower and so the fang is formed, its soft substance becoming smaller and smaller through the progress of calcification around it, till nothing but a minute central pulp cavity is left, through which the vessels and nerves pass. If the tooth be a molar, a separate cap of dentine is formed at first for each cusp, while when the crown has been formed, the development of the papilla becomes modified by the cessation of its growth in certain parts (with corresponding ingrowths from the alveolus), so that it becomes subdivided into as many parts as the tooth is to have roots. The soft tissue left is the foundation of the future roots, the pulp of the tooth now adhering only by them instead of by one undivided soft body, as is the case where there is to be but one root.

From the epithelial sac of each growing first (or *milk*) tooth, a little diverticulum is given off, containing a continuation of the primitively inflected epithelium, and against this, another small papilla rises and imbeds itself, and thus the foundation of each second or permanent tooth is laid. The relations of the milk and permanent teeth have been already given in the second chapter.

As the teeth are formed, so also are the bony walls of the alveoli which grow up and come to surround and embrace them.

The *formation of the dentine* of the teeth takes place by gradual transformation of the surface of the dental papilla (consisting of round nucleated cells in a clear matrix) in such a way as to leave the dental tubuli open, as already described.

The *enamel* is formed by more complete transformation into mineral substance of the epithelial enamel organ, while the *cement* is formed by the ossification of the connective tissue immediately surrounding the dental papilla, and leaving not only tubuli, but as we have already seen, corpuscles similar in form and nature to the corpuscles of true osseous tissue.

The LIVER arises as two diverticula given off from each side of the alimentary canal, immediately behind the stomach (Fig. 155, *h*), each diverticulum consisting of both mesoblast and hypoblast. The former thickens greatly, and becomes very vascular, while canals from the two primitive diverticula extend and ramify within the cylinders of anastomosing cells which it builds up. The growth of this organ is extremely rapid. At first the liver is almost quite symmetrical in form, its right and left lobes being nearly equal. The *gall-bladder* arises as a special diverticulum of both hypoblast and mesoblast.

The PANCREAS appears as a bud from the left side of the duodenum, where both hypoblast and mesoblast are thickened; canals lined with the former ultimately being developed within the latter.

The SALIVARY GLANDS arise in a similar manner at the anterior end of the elementary tube. They differ from the pancreas, however, inasmuch as their cavities are lined with *epiblast*, since this it is which forms the lining of the buccal invagination.

The PERITONEUM, so complicated in the adult, arises as simply the lining membrane of the adjacent surfaces of the two diverging plates (somatopleure and splanchnopleure), into which each ventral lamina splits. Therefore, for a time, the primitive peritoneal cavities of the two sides are continuous with each other, not on the ventral side of the embryo only, but, as before pointed out, over its back, between those doubled folds of somatopleure which ascend on all sides to form the amnion (Fig. 148, $^{2-5}$).

As the somatopleures descend and gradually embrace the alimentary canal—formed by the splanchnopleures—they enclose more and more the peritoneal cavity, and when they come to meet together below, they do so completely (Fig. 147, C, D).

It has already been seen that the divergence of the middle part of the alimentary tube from the vertebral column produces an incipient mesentery. By a continuation of this process the alimentary canal comes to be slung, from the skeletal axis, in a mesenteric peritoneal fold. With the increasing complexity of contortion into which the alimentary canal is thrown by its great increase in length, a corresponding increase of complexity is induced in the mesenteric folds by which it is slung. A pouch of it, having of course four walls, becomes protruded ventrally between the stomach and transverse colon, and so forms the omentum.

§ **14.** The BLOOD makes its first appearance in the interior of the primitive BLOOD-VESSELS, as already described. Both blood and blood-vessels begin to appear first in that layer of the blastoderm which is immediately adjacent to the embryo.

Certain of the primitive mesoblastic cells of the embryo become masses of corpuscles in fluid, enveloped by more solid nucleated protoplasm—the primitive walls of the vessels. These arise, as before explained,* from the junction of radiating processes of adjacent cells, the cavities of which open one into another. Blood-vessels are at first confined in the embryo's body to the splanchnopleure.

The HEART arises as an elongated cavity in the splanchnopleure of the anterior end of the embryo. It consists at first merely of nucleated cells, and its rythmical contractions begin while in this incipient, merely cellular condition, and before the muscular fibres, which subsequently arise, are developed. Its first form is that of an elongated vesicle, or tube, into the posterior end of which two veins open, while a large artery proceeds from its front end. It increases in size and thickness, and bends over in a crescentic loop, projecting downwards and towards the right. At the same time two slight constrictions divide it more or less into three successive portions. The hindermost of these (that into which the two veins open) becomes the future auricles. The next portion becomes the ventricles, while the most anterior segment, from which the great artery proceeds, is called the *bulbus arteriosus*. As the heart becomes more and more bent, the auricular portion approaches the

* P. 331.

ventricular portion, which latter comes to lie transversely. Meantime a septum grows up, dividing the ventricular part into a right and a left chamber. The septum extends on into the bulbus, which becomes divided into two channels, those of the aorta and of the pulmonary artery respectively. As soon as the ventricular septum is complete, another septum begins to divide the auricular portion into a right and left chamber, but this septum remains incomplete even at birth, when an aperture, the *foramen ovale*, still remains, and allows the blood to pass directly from the right to the left auricle without passing through the lungs. It is the existence of this perforation in the new-born kitten * which renders the drowning of it so long a process.

The more important ARTERIES arise as follows. The aortic bulb gives off at first two arteries which run forwards till they reach the first visceral arch, inside which they pass upwards to beneath the spine, where they unite together to form the incipient dorsal aorta. As the length between the most anterior part of these primitive aortic arches and the heart, lengthens (from the growth of the embryo), other arches successively arise from the forwardly extending bulb, and ascend to the backwardly extending root of the dorsal aorta, forming, as it were, a succession of short cuts on each side to the dorsal aorta (Fig. 156, 1 2 3 4). Four vessels thus arise on each side behind the first, and respectively ascend inside successive visceral arches to the aorta. There are thus five such ascending arches developed on each side, though only three exist at the same time, the earlier and more anterior disappearing as the later ones arise.

Ultimately the fourth arch of the left side persists, grows, and becomes the arch of the adult aorta. That of the right side becomes the innominate and right subclavian and carotid arteries. The more anteriorly situated arches become transformed into branches of the carotids. The fifth arch disappears on the right side altogether, but that of the left becomes the pulmonary artery, a communication between it and the great aorta persisting till a little after birth as the *ductus arteriosus* (Fig. 157, *d a*), a relic of which is seen in the fibrous cord which connects together these arteries in the adult.

The descending aorta at first gives off on each side a large *omphalo*-meseraic artery (Fig. 156, *oma*), which goes to the vitelline sac, or umbilical vesicle; but these branches dwindle as the aorta comes to give origin to two other considerable and more posteriorly situated arteries (*ua*) called *umbilical* (the future hypogastric ones), which proceed into the allantois and placenta. From each umbilical artery a comparatively small branch (*Ila*), the future *iliac* artery, is given off, and goes to the incipient pelvic limb.

In the process of their DEVELOPMENT the more notable VEINS undergo remarkable changes. The first important veins to appear are two which pass upwards from the umbilical vesicle to the heart, and are called the right and left *omphalo-meseraic* veins (Fig. 156,

* I have found this foramen still open a week after birth.

omv), and which, as it were, lay the foundation of the future portal and hepatic veins. Before entering the incipient auricular end of the primitive heart, these omphalo-meseraic veins first unite into a common trunk and then dilate into a venous chamber, which bears the name of *sinus venosus* (Fig. 156, *S*), and opens directly into the heart.

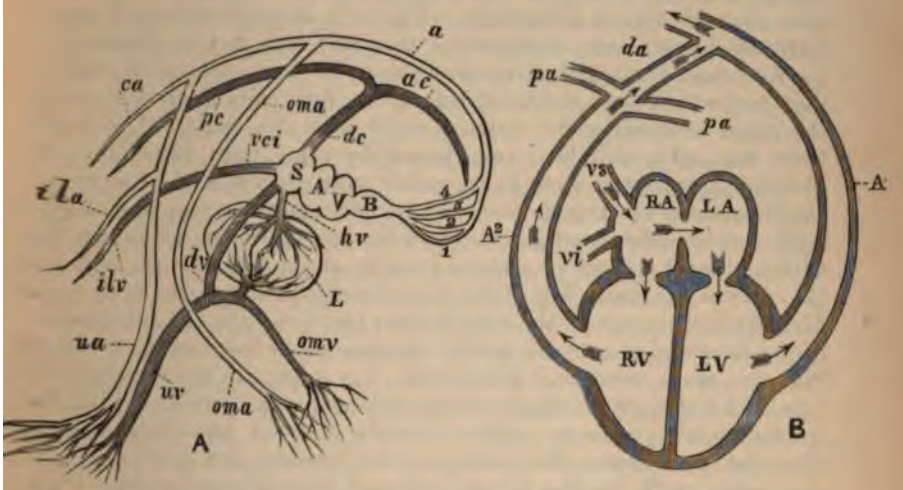


Fig. 156.—Diagram of Fœtal Arteries and Veins. Very early condition. The Arteries and Veins of one side only are represented to avoid confusion.

S. Sinus venosus.
A. Auricle.
V. Ventricle.
B. Bulbus arteriosus.
L. Liver.
1, 2, 3, 4. Aortic arches.
a. Dorsal aorta.
oma. Omphalo-meseraic artery to umbilical vesicle.
ua. Umbilical artery (to allantois).
ila. Iliac artery to incipient hind-limb.
ca. Caudal artery.
omv. Omphalo-meseraic vein.
uv. Umbilical vein.
dv. Ductus venosus.
hv. Hepatic vein.
ilv. Iliac vein.
vci. Inferior vena cava.
pc. Posterior cardinal vein.
ac. Anterior cardinal vein.
dc. Ductus Cuvieri.

Fig. 157.—Diagram of the Fœtal Circulation through the Heart and Aorta. Condition of Heart and Great Vessels at Birth.

RA. Right auricle.
LA. Left auricle.
RV. Right ventricle.
LV. Left ventricle.
*A*¹. Great aorta.
*A*². Second aortic arch (afterwards pulmonary artery).
pa, pa. Incipient branches to lungs
da. Ductus arteriosus, which at first places the two aortic arches in direct communication. The arrows indicate the course of the blood, one going directly from the right to the left auricle through the foramen ovale of the as yet incomplete inter-auricular septum.

Soon two elongated venous trunks make their appearance beneath, and parallel to, the primitive vertebral column (*ac* and *pc*), each such vein sending down a branch, called a *ductus Cuvieri* (*dc*), to the sinus venosus. That part of each of these two trunks which runs backwards from the head end of the embryo to its ductus Cuvieri, is called an *anterior cardinal* vein. That part of each of these trunks which runs forwards from the hinder part of the embryo to the ductus Cuvieri of such trunk is called a *posterior cardinal* vein, which ultimately become the azygos vein. Before the commence-

ment of the placental circulation, the only important veins besides the cardinal ones are the omphalo-meseraic veins; but with the beginning of the placental circulation two veins, called the *right and left umbilical veins* (*uv*), come from the placenta, pass up the allantois and join the omphalo-meseraic veins at their entrance into the liver. The right omphalo-meseraic vein and the right umbilical vein soon disappear altogether. The left omphalo-meseraic vein sinks by degrees into comparative insignificance, but is joined by the now more important mesenteric veins. Of the vessel thus formed, that part which is on the heart side of the liver, ultimately becomes the vessel connecting the hepatic veins with the heart. The left (now the only) umbilical vein, joined by veins from the anterior abdominal walls and other parts, unites with what was the common omphalo-meseraic trunk, now become the portal vein, and also sends out branches (portal veins) into the growing liver, while much of the blood it brings is conveyed on by an undivided vein, called the ductus venosus (Fig. 156, *dv*), directly to the sinus venosus. Meantime other veins—the *hepatic veins* (*hv*)—form in the substance of the liver and open close beside the opening of the ductus venosus into the sinus venosus. Thus what was originally the combined trunks of the omphalo-meseraic and umbilical veins persists till birth as the ductus venosus, while diversely directed branching veins (forming two systems, the portal and the hepatic), are developed in connection with it—the portal system of veins diverging into the liver from near the proximal end of the ductus venosus, while the hepatic veins converge towards the vicinity of the distal end of the ductus venosus.

Meanwhile, concomitantly with the incipient development of the pelvic limbs, there arises the great system of the *vena cava inferior* (*vci*). This is formed by the junction of the veins of the legs and pelvic viscera (the incipient *external* and *internal iliac* veins) into a median trunk, which receives accessions from the kidneys (*renal* veins), and runs on beneath the great dorsal aorta to the heart, where, intruding upon the junction of the hepatic veins and sinus venosus, it ultimately absorbs, as it were, the latter chamber altogether, and thus the hepatic veins come in the adult to open into the vena cava inferior.

During this period, the right ductus Cuvieri becomes attached to the developing right auricular part of the heart, and while the anterior cardinal veins become large and important, as the *jugular* and *subclavian* veins, the posterior cardinal veins become relatively reduced into the right and left vena azygos. Then a transverse communicating branch, which connects the two jugular veins, rapidly enlarges, while the left ductus Cuvieri diminishes and disappears. This transverse branch becomes the *left innominate* vein, and thus the right ductus Cuvieri (having now the right jugular and subclavian veins brought into connexion with it) becomes transformed into the *vena cava superior*. The right azygos vein (the old right posterior cardinal vein) opens at last, as at first,

into what was the right ductus Cuvieri and what is ultimately the vena cava superior. The left azygos veins (the old left cardinal vein) opens at last, as at first, into what was the right ductus Cuvieri, and what is ultimately that part of the superior intercostal vein which is nearest to the left innominate vein.

After birth and the cessation of the placental circulation, the ductus venosus diminishes and becomes obliterated, save as that fibrous cord, the round ligament which traverses the liver. The umbilical vein also disappears, save as that part of the round ligament which extends from the umbilicus to the liver. Thenceforth all the blood returning from the stomach and intestines is compelled to circulate through the portal and hepatic veins on its way to the heart.

Those parts of the umbilical arteries which are within the body—the *hyogastric* arteries—similarly abort where they intervene between the bladder and the umbilicus, becoming merely two fibrous cords. Those parts which intervene between internal iliacs and the side of the bladder, persist as the *superior vesical* arteries.

The DEVELOPMENT of the LYMPHATIC SYSTEM resembles more or less that of the blood-vascular system. The small *lymphatics* originate by the junction of nucleated cells, and they spread and increase through the development of peculiar cells, which branch out and join fine processes given off from the lymphatics formed earlier. The *lymphatic glands* appear to be developed from clusters and aggregations of lymphatic vessels from which diverticula grow out. The *lymphatic corpuscles* probably originate from subdivision of cells contained within the early formed lymphatic vessels and glands, also in the spleen and perhaps in the thyroid and thymus glands.

The fluid lymph may be regarded, like the fluid blood, as the blastema of a tissue of which the white corpuscles represent the nucleated cells.

§ **15.** The LUNGS are at their origin small outgrowths from the alimentary canal (Fig. 155, *l*). This canal, at a point immediately behind the heart, becomes laterally constricted by two lateral infoldings of its walls, which divide it into a narrower upper, and a broader lower (or ventral) channel, while the lower channel tends to be subdivided by a median longitudinal upgrowth from its floor. This process continuing, three tubes come to be formed, whereof the dorsal one is the future œsophagus, while the two ventral ones become the two lungs, which thus arise as two diverticula, lined with hypoblast, from the ventral aspect of the œsophagus. These little sacs elongate by degrees, and ultimately come to hang by a single and common supporting tube, the future trachea. Ramifications of the primitive cavity into the mesoblastic tissue surrounding it, form the bronchial tubes, with their branches.

In contrast with the liver, the lungs of the fœtus are exceedingly small, but as soon as the first inspiration has taken place, they rapidly increase in size and weight, while their consistency changes from that of a granular, compact, heavy substance, to a light and spongy texture.

The LARYNX first becomes visible by the rudiments of the cartilages which appear about the primitive glottis, the arytenoids seeming to be the first, and the epiglottis the last to appear.

The SPLEEN is formed entirely from the mesoblast, a thickening of which appears on the left side of the stomach, near the pancreas. No prolongation from the alimentary canal ever enters it, or even appears in connexion with it.

The THYROID BODY arises as a small diverticulum, lined with hypoblast, from the anterior wall of the pharynx, and consists of isolated vesicles, within which are rounded cells, the vesicles multiplying by constriction and division—or by budding out and separation—of such protruded parts. It is larger relatively in the fœtal and young condition than in adult age.

The THYMUS GLAND is a body which makes its appearance as a tube with granular contents, surrounded by tissue into which small vesicles bud forth, laterally, from it—which vesicles themselves again branch. The thymus is relatively larger at birth than subsequently but it still remains of large size, even at maturity.

§ 16. The first URINARY ORGANS which make their appearance in the embryo are not the kidneys, but certain temporary urinary glands called the WOLFFIAN BODIES (Fig. 151), which early attain a large relative size. Afterwards their place is taken by the true kidneys. The Wolffian bodies entirely losing all secreting power, and more or less aborting, become (in one or the other sex) either important or merely functionless appendages of the generative organs.

The Wolffian bodies make their appearance in the embryo (at a time when the intestinal canal still communicates widely with the umbilical vesicle) as a slight ridge on each side of the primitive mesentery, and each body grows to be a reddish oblong mass beside the vertebral column, reaching from the heart to the hinder end of the abdomen. It consists of a series of tubes all opening into a duct which runs along the outer border of the Wolffian body. Each tube is somewhat convoluted and dilated at its blind end as a Malpighian body, into which a vascular glomerulus enters, just as in the true kidney—the Wolffian bodies being very vascular. The ducts of the two Wolffian bodies open near together into the root of the allantois.

The first parts to be developed of the Wolffian bodies are their ducts, which appear to arise from a series of invaginations (from the primitive pleuro-peritoneal cavity) into that part of the mesoblast which lies in the angle between the diverging somatopleure and splanchno-pleure. The blind ends of these invaginations grow out laterally and coalesce, so as to form a rod traversing the mesoblast antero-posteriorly, while the invaginations, which originally led from the peritoneal sac, close up and disappear. The central part of the rod developes a cavity, and thus the tube of the Wolffian ducts comes to be formed. After this, diverticula bud off laterally from this duct, and so the tubes which end in the Malpighian bodies come to be formed.

While the Wolffian bodies are forming, another, single, invagination is formed on its inner side, and this closes over, extends, and becomes a tube called the MULLERIAN DUCT. The two Mullerian ducts, which end blindly at their anterior end, extend backwards, meet and coalesce where they open (side by side and between the two Wolffian ducts) into the proximal part or root of the allantois.

The ALLANTOIS itself, as has already been said, grows forth as a membranous sac from the hinder end of the ventral aspect of the primitive alimentary canal, and extends out between the somatopleure and splanchnopleure to the inner surface of the chorion in the umbilical cord.

As the visceral plates of the somatopleure close round the belly of the embryo, they come finally to embrace the umbilical cord where it quits the body.

The part of the allantois which is within the abdominal cavity, becomes differentiated into what are ultimately (1) the proximal part of the urethra, (2) the bladder and (3) the *urachus:* the urachus being that part of the allantois intervening between the bladder and the umbilicus, or navel. The cavity of the urachus becomes narrower and narrower till it closes, and so this part becomes transformed into a ligament, with traces, perhaps, of its primitive cavity. The proximal part of the allantois opens at first into the hinder end of the primitive alimentary cavity, but by degrees a partition (the future perineum) grows forwards horizontally, and divides the dorsal alimentary chamber, or rectum, from the ventral *urogenital sinus*, into which latter (the commencing proximal part of the urethra) the Wolffian and Mullerian ducts open (Fig. 158, A).

The KIDNEYS begin to appear as two oval dark-coloured bodies, each placed behind and above the very much larger Wolffian body of the same side. Nevertheless, each kidney is at first larger, compared with the bulk of the whole body, than in the adult.

The kidneys themselves arise subsequently to the development of their ducts, the *ureters*. These latter seem each to be formed from a dilatation of part of the Wolffian duct, which becomes constricted, and so the ureter arises as a separated-off diverticulum of such duct. This diverticulum, however, grows downwards and backwards, and opens, not into the urogenital sinus, but into the bladder (Fig. 158, A, *b*) which is separated from that sinus by a constriction.

From the anterior end of each newly formed ureter diverticula grow forth into the mesoblast, and these diverticula lengthen, become greatly contorted, and end in true renal Malpighian corpuscles. It may be, however, as some contend, that the various parts arise separately in the formative tissue, each part at first being solid, but subsequently acquiring a cavity, and all ultimately uniting together.

The SUPRA-RENAL CAPSULES arise quite independently of the kidneys. For a time they are much larger than the last named organs. They appear to originate as a single mass in front of the kidneys, subsequently becoming divided into two lateral organs.

The TESTES appear after the Wolffian bodies, but before the

kidneys, as two small whitish oval masses of tissue, placed one on the inner side of each Wolffian body, and arising as buds from the mesoblast, between the diverging somatopleure and splanchnopleure. Soon the cells of which they are composed become divided by septa of connective tissue, and the cells themselves grow into the *tubuli seminiferi*. Meanwhile, the tubes of the Wolffian body become approximated to, and ultimately united with, the testis, and form the *vasa efferentia* and *coni vasculosi* of the *epididymis*, the duct of the Wolffian body becoming the *vas deferens*, some of its detached tubes forming the vas aberrans and Organ of Giraldes.* The testes ultimately descend from the abdominal cavity into the scrotum which is formed by the median junction of two folds of skin, which grow from the sides of the external opening of the urogenital sinus.

The *penis* first appears as a small recurved process projecting from the front margin of the urogenital opening (Fig. 158, A, *rp*) consisting of what are to be the corpora cavernosa, with a portion of corpus spongiosum at its distal end and extending down the grooved ventral, or posterior, surface of the developing organ. The lateral margins of this groove grow over and close, so converting the groove into a canal—the *spongy portion of the urethra*. This canal then opens posteriorly into the front end of the urogenital sinus which still opens externally at the root of the penis, though separated from the anal aperture by a transverse partition, the incipient perineum. By degrees this inferior opening of the urogenital sinus grows over and closes, and thus the spongy urethra comes to form one continuous tube with the urethra as it quits the bladder, while the posterior end of the ventral surface of the penis becomes continuous with the medianly coalesced lateral folds which have formed the scrotum and invested the place where was the external opening of the urogenital sinus at the root of the developing penis.

The OVARY arises just as does the testis, and is at first indistinguishable from it. Soon, however, it comes to differ somewhat in shape, and ova and Graafian vesicles arise from the very first within it. It does not form the same kind of adhesion to the Wolffian body as do the testes, but its stroma is formed by outgrowth of tissue into it from the Wolffian body. A fibrous cord, the round ligament, comes to connect the ovary with the pubis through the inguinal ring, but the ovary never passes outside the abdominal cavity, though it descends a little from its primitive position. It becomes wrapped round by the fold of peritoneum, the *broad ligament*, which is reflected on each side from the uterus, so that no discharge of its contents can take place without rupture of its peritoneal investment.

The *vagina and uterus* arise as the partially conjoined hinder ends of the two Mullerian ducts, which open into the dorsal wall of the urogenital sinus (Fig. 158, B). The simple tube comes by degrees to alter in size and structure in different regions, its deeper portion becoming very muscular (as the uterus) and separated from the hinder part, the vagina, by a constriction forming the os uteri

* See ante, p. 244.

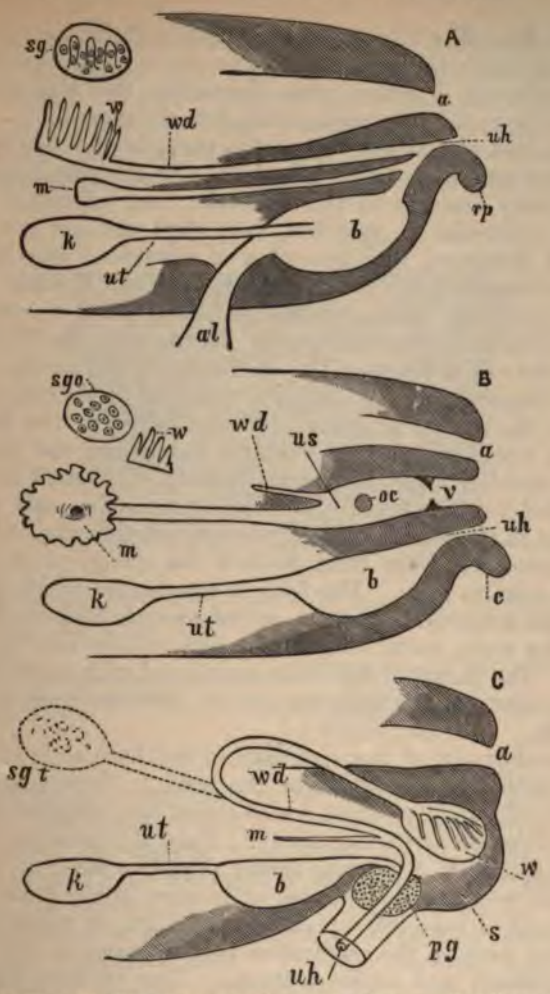


FIG. 158.—DIAGRAM OF THE DEVELOPMENT OF GENERATIVE ORGANS. THE BODY IS SUPPOSED TO BE CUT THROUGH VERTICALLY, AND THE URINARY AND GENERATIVE ORGANS OF THE LEFT SIDE TO BE VIEWED LATERALLY.

A. The earliest or neutral condition, the sexual gland (*sg*) being as yet undifferentiated into either ovary or testis, and the Wolffian body (*w*) and duct (*wd*), and the Mullerian duct (*m*), all co-existing with the permanent kidney (*k*) and ureter (*ut*), the papilla (*rp*) on the ventral side of the opening of the urethra (*uh*) being rudimentary.

B. Here the neutral state is changing into the complete female condition. The sexual gland (*sgo*) has become an ovary. The Wolffian body and duct (*w* and *wd*) have almost aborted. The remnant of the Wolffian body (*w*) has become the par-ovarium and Gaertner's duct. The Mullerian duct (*m*) has expanded and opened at its free end, and become a Fallopian tube, the lower end of which has coalesced with its fellow of the opposite side to form the vagina (*v*) and uterus (*us*). The opening of the cornu of the right side is seen at *oc*.

C. Here the neutral state is changing into the complete male condition. The sexual gland (*sgt*) has become a testis, and has travelled backwards and downwards into the scrotum (*s*)—its original position being indicated by dotted lines. The Mullerian duct (*m*) is reduced to a rudiment, the prostate has developed (*pg*), and the rudimentary papilla has become a relatively large organ (*p*), which is represented as truncated.

a. Anal aperture. *al*. Allantois. *b*. Bladder.
c. Clitoris. *k*. Kidney. *m*. Muller's duct.
oc. Opening of right uterine cornu into uterus.
pg. Prostate gland.
rp. Rudimentary papilla, which becomes the penis in the male.
s. Scrotum.
sg. Undifferentiated sexual gland.
sgo. Ovary. *sgt*. Testis. *uh*. Urethra.
us. Uterus. *ut*. Ureter. *v*. Vagina.
w. Wolffian body. *wd*. Wolffian duct.

(Fig. 158, B). The two upper ends of the Mullerian ducts, above where they begin to form the uterine cornua, open at their deep ends, as already described, thus becoming the Fallopian tubes, which lead from the peritoneal cavity into the uterus.

The *fundamental similarities* of the parts in the two sexes may be expressed as follows (Fig. 158, A, B, C): the primitively formed Wolffian body becomes in the male the vasa efferentia and coni vasculosi, otherwise it vanishes, save that the *vas aberrans* and *hydatid* of Morgagni, with the organ of Giraldes,* may be its more or less persistent relics. In the female both the Wolffian body and its duct practically disappear, the *parovarium* and *Gaertner's duct* being persistent remnants of them. In the male the Wolffian duct becomes the vas deferens. The Mullerian ducts, on the contrary, entirely disappear, except that the relics of their conjoined ends persist as the *utricle* or *sinus pocularis*; while in the female, the Mullerian ducts become the oviducts, the uterus and the vagina. Thus the utricle is the minute male uterus. The small body formed on the front margin of the cloaca becomes in the male the penis, the clitoris in the female. The groove which traverses it below and behind, closes in, in the male, to form the spongy urethra; in the female it remains open. The folds of integument which lie on each side of the urogenital aperture, persist as such folds in the female, but, in the male, unite ventrally in the middle line to form the scrotum. The glands of Bertholin correspond with those of Cowper, but the prostate of the male has no, as yet discovered, analogue in the female.

The development of the spermatozoa has been already described together with the description of the testis.† Ova arise simply as epithelial cells, such as those which invest the incipient ovary, and generally line the peritoneal cavity. They also arise as (and from amongst) epithelial cells more deeply placed in the ovary; but it is not certain whether such deeper cells arise inside quasi-glandular tubes formed of inflected superficial epithelium, or whether they are deep-seated because the connective tissue stroma of the ovary has grown outwards and enclosed them.‡ The ordinary sized germ-epithelial cells are about $\frac{1}{2500}$ of an inch in diameter. The substance of the ovary by which these cells become enclosed, is an outgrowth from the Wolffian body.

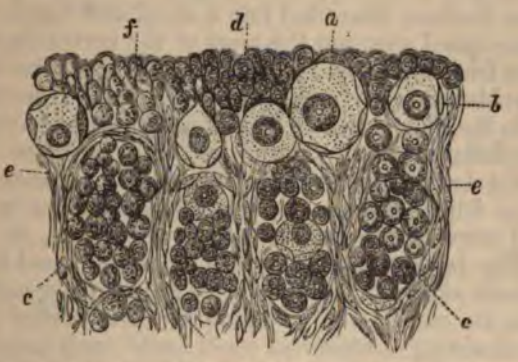
The epithelial cells become thus enclosed in groups or "nests," and some of them, enlarging in size and acquiring much clear protoplasm around their nucleus, become what are called *primitive* or *primordial ova*, which average about $\frac{1}{1000}$ of an inch in diameter. Other adjacent epithelial cells divide and multiply, and form a

* See *ante*, pp. 244 and 250.

† See *ante*, p. 245.

‡ As is the opinion of Mr. F. Balfour. See Quarterly Journal of Microscopic Science, October, 1878, p. 418, and Embryology, vol. i., p. 47. See also a paper by Dr. Foulis, in the Trans. of the Roy. Soc. of Edinb., vol. xxvii., p. 345, and another by Mr. E. A. Schäfer, on the Pro. Roy. Soc., 1880, p. 245.

cellular investment, or follicle, around the primordial ova, and ultimately grow into the tunica granulosa within the Graafian vesicle. Sometimes two or more of the ova-forming epithelial cells of a nest, will coalesce and form a large protoplasmic mass with two or more nuclei, and thus a cell may arise and then be nourished by appropriating the substance of other cells. An enlarged epithelial



159.—PORTION OF THE OVARY OF A KITTEN ABOUT THREE WEEKS OLD, SHOWING THE GERM-EPITHELIUM AND PRIMORDIAL OVA, WITH LARGE EGG-NESTS MORE OR LESS SURROUNDED BY STROMA (*Foulis*).

a. Primordial ova.
b. Smaller cells, resulting from the fission of larger epithelial cells, and beginning to form the membrana granulosa.
c. Large clusters of germ epithelial cells, *i.e.* large egg-nests.
d. Large germ epithelial cells.
e. Stroma of ovary.
f. Germ epithelial cells.

ll, or primordial ovum, when it has become enclosed in a follicle, comes a "permanent ovum." The protoplasm, or vitellus, accumulates about the nucleus or germinal vesicle, which developes a nucleolus, or spot, while the zona pellucida forms either just within or externally to a delicate membrane investing the vitellus. The ovum, with its epithelial lining and external investment of fibrous vascular stroma, is a "Graafian follicle." At first the ovum itself is closely embraced by the follicle. Afterwards the follicle greatly enlarges, and its contents separate into (1) the cells of the membrana granulosa, lining the vesicle and enclosing (2) a fluid, (3) the ovum, and (4) an aggregation of cells— the discus proligerus—which remains adherent around the ovum. The ovary at first contains thousands of incipient ova, but the great majority disappear as development proceeds. When the kitten is but from two to four weeks old a very large part of the whole ovary consists of egg-clusters, but at five months old there is only a zone of young eggs left immediately beneath the tunica albuginea.*

§ 17. The NERVOUS SYSTEM, though a unity in its fully formed condition, is more *diverse* in its *origin* than is the alimentary system. The latter system, as has been shown, arises as a groove

* See Dr. Foulis, *l. c.*, p. 373.

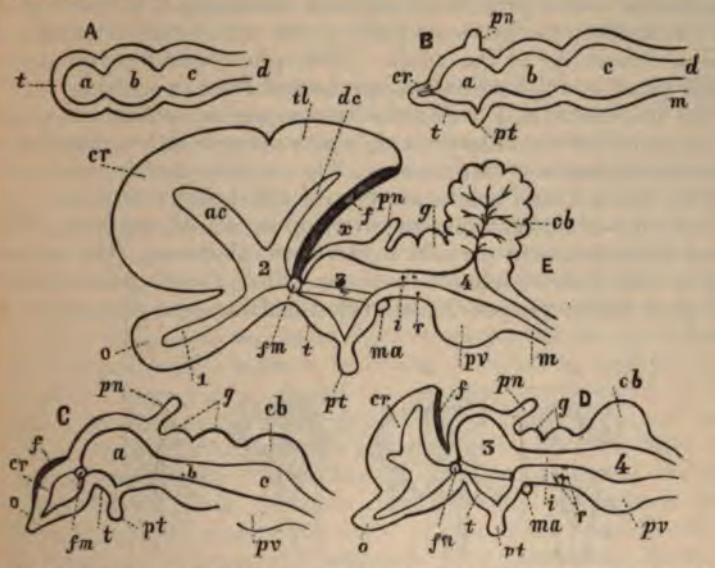
of the mesoblast, open downwards and lined with hypoblast, whi gradually becomes converted into an elongated canal, from whi secondary, more or less ramifying tubes (also lined with contin tions of hypoblast) grow out.

The nervous system also arises as a longitudinal axial groove the mesoblast (lined with epiblast) extended above the alimenta groove and open in the opposite direction, namely, upwards. Th groove also becomes converted into a canal and forms the basis the cerebro-spinal axis, but the mass of the nerves do not arise outgrowths from it, but by modification and transformation of pa of the mesoblast into nerve substance, such incipient nerves becomi attached to the independently formed cerebro-spinal axis.

The medullary groove (except its more anterior part, whi becomes the brain, as hereinafter described,) becomes the SPINA MARROW, as follows:—The ascending dorsal laminæ meet togeth above and convert the groove into a canal, first, in the cervic region. The layer of epiblast which lines the canal thickens ver much on each side, its innermost layer (of columnar cells) becomin epithelium, its outer layer becoming the grey matter of the spin cord, and consisting of numerous small nuclei, each surrounded by a aggregation of protoplasm. Outside this the white matter of th spinal cord is formed by transformation of the cells of the adjacen portion of mesoblast. The central canal of the developing cor having become relatively elongated from above downwards throug the lateral thickening of its walls, becomes next constricted by a ingrowth from each such lateral wall. These ingrowths continue t they meet, the canal becoming thus divided by a transverse partitio into a dorsal and ventral canal. Then the roof of the dorsal can becomes absorbed, and this dorsal part of the primitive medullar canal (now again become a groove) is the *posterior* (dorsal) *media fissure* of the adult spinal cord. Meantime the white substance the ventral aspect of the developing myelon grows out on each side leaving, however, a median interspace which becomes in the adul the *anterior* (ventral) *median fissure*, which has thus quite anothe origin and nature from the posterior (dorsal) median fissure. Tha part of the primitive canal which is on the ventral side of the trans verse partition (formed by the coalesced lateral ingrowths abov mentioned,) persists as the *canalis centralis* of the spinal cord of th adult. The *cervical* and *lumbar* enlargements of the spinal cor soon make their appearance, and the canalis centralis is also some what enlarged in those two regions. The myelon is at firs co-extensive with the neural canal of the skeleton, so that there i no cauda equina. Afterwards, however, its growth does not kee place with that of the skeleton, and thus the roots of the hindermos spinal nerves become more and more elongated, and the formatio of a *cauda equina* thence results.

At its proximal end the spinal cord merges into the medull oblongata by the thickening of the floor and sides of the primitiv

roove and the approximation of the roof of the canalis centralis to
ie dorsal surface.



g 160.—Diagram of Brain Development, to show the essential relations of its parts.

- The brain in its earliest condition of three hollow vesicles, the cavity of which is continuous with the wide cavity (*d*) of the primitive spinal marrow (*m*). The brain substance forms an envelope of nearly equal thickness throughout. The wall of the anterior end of the first vesicle is the lamina terminalis (*t*).
- Here the first vesicle or fore-brain has developed the pineal gland (*pn*) above, and the pituitary body (*pt*) below, the cerebral hemisphere (*cr*) are beginning to bud forth from the front part of the first vesicle.
- The cerebrum is here enlarged, and has begun to bud out into the olfactory lobes (*o*). The cavity of the cerebrum (or incipient lateral ventricle) communicating with that of the olfactory lobe in front, and with that of the first cerebral vesicle (*i.e.*, with the third ventricles) behind. The latter communication takes place through the foramen of Monro (*fm*). The walls of the three cerebral vesicles are becoming unequal in thickness, and the cavity of the middle vesicle (*b*) is becoming reduced in relative size, as the *iter a tertio ad quartum ventriculum*. The thickened upper part of the cerebrum (*f*) is what is to become the fornix. The thickened roof of the middle vesicle has divided into the corpora quadrigemina (*g*), and the roof and floor of the third cerebral vesicle (*c*) have thickened into the cerebellum (*cb*) and pons Varolii (*pv*).
- The figure shows the cerebrum more enlarged, with its cavity bifurcating into the prolongations (the cornua). The fornix has come to look backwards, and two lines (below the figure 3) indicate its prolongation downwards and backwards into the corpora mammillaria (*ma*).
- E. Here the cerebrum is still more enlarged, extending backwards over the corpora quadrigemina and part of the cerebellum. The fornix is shown bordering the descending cornu (*dc*) of the lateral ventricle, and extending into the temporal lobe (*tl*).

a. Fore-brain.
oc. Anterior cornu
b. Mid-brain.
c. Hind-brain.
cb. Cerebellum.
cr. Cerebrum.
dc. Descending cornu.
d. Cavity of the medulla.
f. Fornix.
g. Corpora quadrigemina.
i. Iter a tertio ad quartum ventriculum.
m. Medulla oblongata.
ma. Corpora mammillaria.
o. Olfactory lobe.
pv. Pons Varolii.
pn. Pineal gland.
pt. Pituitary body.
r. Crura cerebri.
t. Lamina terminalis.
tl. Temporal lobe of cerebrum.
x. Space enclosed between the backwardly-extended cerebrum and the much narrowed roof of the third ventricle, which has now become the velum interpositum.
2. Lateral ventricle.
3. Third ventricle.
4. Fourth ventricle.

The BRAIN is first indicated by the expansion of the pre-axial
nd of the medullary groove into what becomes the first or most
nterior cerebral vesicle or *fore-brain*. To this succeed two other

vesicles, namely, those of the *mid-brain* and the *hind-brain*. T
fore-brain, called also the *deutencephalon*, contains the anter
termination of the primitive medullary canal, and this becomes t
third ventricle; the pre-axial wall of the first vesicle becoming t
lamina terminalis of the adult. The optic thalami, optic nerv
pineal gland and infundibulum, are formed from this vesicle.

The mid-brain, called also the *mesencephalon*, contains that p
of the primitive medullary canal, which ultimately becomes the s
a tertio ad quartum ventriculum. The *corpora quadrigemina* abo
and the *crura cerebri* below, are formed about this ventricle.

The hind-brain contains the cavity of the fourth ventricle, whi
is not all roofed over dorsally by nervous substance. The anteri
part of this third vesicle is sometimes called the *Epencephalon*, an
this gives rise to the *pons Varolii* below and the *cerebellum* above, th

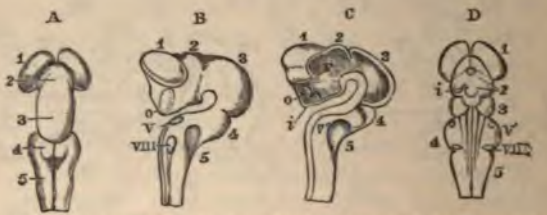


Fig. 161.—Four Views of the Brain of an Embryo Kitten in the stage where it fir
divides into the five Cerebral Rudiments—showing the actual proportio
of the parts. Magnified three diameters.

A. The brain, seen from above.
B. From the side.
C. Vertical section, showing the interior.
D. From below.
1. Cerebral hemispheres, or prosencephalon.
2. Region of the third ventricle—the thalamencephalon or deutencephalon.
3. Region of the corpora quadrigemina, or mesencephalon.
4. Cerebellum or epencephalon.
5. Medulla oblongata, or myelencephalon.
o. Optic nerves.
V. Fifth pair of nerves.
VIII. Glosso-pharyngeal and pneumogast
nerves.
i. Infundibulum.
m'. General ventricular cavity, opening an
riorly into the lateral ventricle by the fo
men of Monro.

latter arching back and covering over the hinder part of the fourt
ventricle. The posterior part of the third vesicle or hind-brain,
sometimes called the *myelencephalon* or *metencephalon*, and this giv
rise to the *medulla oblongata*.

From the anterior part of each side of the fore-brain another vesic
grows out. These together form the *cerebral hemispheres*, called al
the *Prosencephalon*, which give rise to the *corpora striata*, *fornix* a
corpus callosum. The cavity within these outgrowths are the *later
ventricles*, and the aperture by which they are continuous with t
cavity of the Deutencephalon (or third ventricle) is the futu
foramen of Monro.

From the anterior part of the floor of each cerebral hemisphe
yet another vesicle buds forth. This is the future olfactory lobe
nerve, called also the *Rhinencephalon*. Each such lobe at first lik
wise contains a cavity continuous with that of the lateral ventricle
its own side; but this olfactory ventricle is obliterated in the adul

The cerebral vesicles as they develope undergo a noteworth

INFLEXION. At first they follow one another in a straight line. Afterwards the fore-brain and mid-brain bend downwards and forwards over the front end of the notochord, while that part of the hind-brain which forms the cerebellum, bends upwards upon the portion which forms the medulla.

The various parts which form themselves out of the three primary hollow vesicles, grow at very different rates. The cavities of the three vesicles and the olfactory lobes remain relatively small, but the increase in bulk of the cerebral hemispheres is much greater than that of the other parts. Moreover these cerebral hemispheres become connected together by an outgrowth of nerve substance from their adjacent sides a little above the fornix, such outgrowth resulting in the formation of a mass of transverse connecting fibres, which become the CORPUS CALLOSUM. This transverse growth comes thus to enclose that space which was originally the deepest part of the great longitudinal fissure, which space is, of course, bounded on each side by a part of the inner wall of one of the cerebral hemispheres. These portions of such inner walls become exceedingly thin and form together the *septum lucidum*, the space included between them and which is bounded above by the corpus callosum, becoming the *fifth ventricle*. It is plain, therefore, that the fifth ventricle is quite different in nature and origin from all the other ventricles of the brain, since these latter are remnants of, or outgrowths from, the primitive medullary groove and canal of the embryo, while the fifth ventricle, on the contrary, is as it were a portion of outside space which has been enclosed and taken into the brain by means of those inward lateral outgrowths which form the corpus callosum.

The FORNIX is formed by two sets of longitudinal fibres, which are developed (one bundle on each side,) from the upper margin of the foramen of Monro, while the median junction of these two lateral bundles form the so-called *body of the fornix*. Thus the fornix is the median part of what was originally the back or underside of the cerebral hemispheres, its body forming part of the outer wall or bag of the cerebral hemispheres enclosing the lateral ventricles. As these hemispheres grow backwards, the two prolongations of the fornix (or its *posterior* pillars,) extend (following the course of the developing "temporal lobe,") backwards and downwards, one in the wall of each hemisphere, as a bundle of longitudinal fibres, such bundle projecting into the descending course of the lateral ventricle as part of the *hippocampus major*. Its *anterior pillars* descend in the *lamina terminalis* to the corpora mammillaria.

The cerebral hemispheres, with the fornix as part of their wall, having grown backwards over the mid-brain containing the third ventricle, the space between the roof of that ventricle, the VELUM INTERPOSITUM, and the body of the fornix which comes to be applied to the velum, is thus essentially the *outside* of the brain, though as a fact it is actually in the very middle of that great complex structure, the brain of the adult. The *velum* consists only of ependyma, the pia mater and the arachnoid. The vascular membranes called

choroid plexuses, are but its margins which have become very vascular, and the choroid plexuses of the lateral ventricles are also (as has been before pointed out) merely portions of the ependyma which have become very vascular, and are by no means intrusions from without into the true cerebral cavity. The vascularity is, in fact, continued on in that portion of the ependyma which lines the foramen of Monro and the lateral ventricles. The membranes which invest the brain externally never enter the ventricles at all, but are (as has been already said) reflected back on the under surface of the fornix.

The THIRD VENTRICLE, which has (as has been said) the velum for its roof, grows out below into the infundibulum. The *pineal gland* is formed in connexion with the roof of the third ventricle from behind the velum. The *pituitary body* comes from the mouth—see p. 343.

The sides of the third ventricle, unlike the rest of its walls, become greatly thickened to form the *optic thalami*, while its anterior wall, the *lamina terminalis*, becomes thickened in places and so forms a band of transverse fibres, the *anterior commissure* (connecting the *corpora striata*) and also a pair of vertical bundles (the *anterior pillars* of the fornix) extending into the fornix above, and into the corpora mammillaria below. The two optic thalami also become connected by two sets of transversely extending nervous structures. The first and more anterior is formed of grey matter and is called the *soft commissure*, the more posterior, formed of nerve fibres, is called the *posterior commissure*. The CORPORA QUADRIGEMINA arise as an outgrowth from the roof of the mid-brain, and one containing a cavity continuous with that of the second cerebral vesicle. The corpora are at first of very large relative size, but they seem, as it were, to lag behind in growth, become solid, and ultimately divided, first into two lateral halves, and ultimately into *nates* and *testes*.

Concomitantly with the development of the corpora quadrigemina, the floor of the mid-brain becomes greatly thickened by the developing crura cerebri, and thus the primitively large cavity of the mid-brain becomes reduced to the very narrow *iter a tertio ad quartum ventriculum*.

Each CEREBRAL HEMISPHERE is also a bag, the walls of which are very unequally thickened. Part of the inner wall, along the descending cornu, is reduced to mere ependyma, with pia mater and arachnoid, so that it tears very easily, the rupture thus produced having (in man) been called the fissure of Bichat and taken for a natural opening. Each *corpus striatum* is a thickening of the outer and under wall of each hemisphere abutting against the front and outer part of the optic thalamus behind it, and forms the axis round which the whole hemisphere is developed.

Slight depressions begin sooner or later to appear on the surface of each hemisphere, the beginnings of the future *gyri* and *sulci*. These increase very gradually as the cerebrum grows upwards and backwards.

The MEMBRANOUS INVESTMENTS OF THE BRAIN arise in different

modes. The *dura mater* is formed from the inner surface of the dorsal plates external to the cells which become the nervous centres. The *pia mater* and the *arachnoid*, on the contrary, are formed by transformation of the outer layer of the primitive brain mass itself. Thus no part of these tissues, whether choroid plexuses or what not, extend and grow into fossæ and cavities of the brain, but they actually arise and are first formed there where they ultimately exist.

The CRANIAL NERVES arise as four small opaque pear shaped masses of nervous tissue, which grow from the epiblast on each side of the hind brain in front of the protovertebræ on each side. Of these four pear-shaped masses (the wider ends of which are directed inwards to the axis of the body), two are placed in front of and two behind the auditory vesicle. The first of these masses becomes the fifth nerve, and bifurcates, one branch becoming the ophthalmic nerve, the other the 2nd and 3rd branches. The second mass becomes the facial nerve. The third mass becomes the glosso-pharyngeal, and the fourth the pneumogastric.

The DEVELOPMENT OF THE EYE is brought about by the concurrence of three different processes or growths. 1. An outgrowth from the brain. 2. An ingrowth from the skin. 3. An upgrowth of the mesoblastic tissue which surrounds the developing eyeball, into a certain part of its interior.

The outgrowth of the encephalon is in the form of a hollow process of the fore-brain, containing a prolongation of its cavity, the future third ventricle—just as the olfactory lobe contains at first a prolongation of the prosencephalic cavity. This ocular outgrowth is called the *primary optic vesicle*. It ultimately developes into a narrow stalk and an anterior distal expansion. The stalks of the two primary optic vesicles are at first placed close to the junction, on each side, of the cerebral vesicle with the vesicle of the third ventricle. Each is at first disconnected with the other altogether, but little by little the root of each extends over to the opposite side of the brain, while their fibres, where they come thus to cross, intermix together, and so a *chiasma* is formed. The distal expansion of each primary optic vesicle gets (by apposition with other structures to be shortly described) doubled in upon itself, so as to become cup-shaped, and to present a concavity forwards and outwards, the *secondary optic vesicle*, or *optic cup*, while by degrees its cavity becomes altogether obliterated, as also that of its stalk.

Meanwhile a depression of the external cuticle has indicated externally the place of the future eye. This depression deepens while its lips approximate till it forms a closed sac lined by the epiblastic epithelium which coated the invagination. This sac becomes applied to the anterior cup-shaped surface of the optic cerebral outgrowth. The walls of the sac then thicken, especially behind, and obliterate its cavity. Its posterior portion certainly becomes the *lens*, and its anterior portion either also becomes part of the lens, or is transformed into the aqueous humour which, if it is not thus formed, is

formed from a growth of mesoblast intervening between the incipient lens and the epiblast. From the margins of the chamber of the aqueous humour, a growth extends inwards on all sides which becomes the iris, and divides the chamber into two portions. The vitreous humour is formed by a growth of mesoblastic tissue up through a fissure left below during the infolding of the primary optic vesicle and formation of the optic cup. This fissure gets gradually closed up, though traces of it, called the *ocular cleft*, may be discerned for a considerable time. The mesoblastic tissue around the eyeball becomes condensed into the *sclerotic*. The external skin in front of

Fig. 162.—SECTION OF THE COMMENCING EYE OF AN EMBRYO, IN THREE STAGES.

A. Commencement of the formation of the lens by depression of a part of C, the epiblast.
pr. The primitive ocular vesicle or nervous outgrowth from the brain, now doubled back on itself by the depression of the commencing lens (*l*).
B. The lens depression has become enclosed, and the lens itself is beginning to be formed within it. The optic vesicle has become more folded back.
C. A third stage, in which the secondary optic vesicle—the upgrowth forming the vitreous humour (*v*)—begins to be formed. The primitive cavity of the cerebral optic vesicle (*pr*) is here reduced to a chink by the still further infolding of that vesicle.

the eyeball developes a fold of membrane above and below. These increase in size, and become the eyelids, their inner lining and the epiblast coating the cornua being transformed into the *conjunctiva*. The eyelids, when formed, become glued together at their margins till nine days after birth. The conjunctiva is continuous with the lining of the lachrymal canal, which latter is a persistent remnant of the fissure, at first wide, which primitively exists between the frontal and the maxillary processes of the embryo.

The DEVELOPMENT OF THE EAR, in so far as it arises by involution of the epiblast, resembles that of the eye, but it differs from it greatly in that there is no outgrowth from the brain corresponding with such epiblastic involution. The first appearance of the future internal ear takes place (at a very early period) on each side of the hind-brain, when an involution of the epiblast forms a pit extending down into the mesoblast, which lies externally to the cerebro-spinal axis of that region. This pit deepens, and its margins close over and unite, so forming it into a closed sac called the *otic vesicle*. This vesicle becomes the *internal labyrinth*. The epiblast forms the endothelium of that labyrinth which contains the endolymph. All the structures external to this, namely, the fibrous structure of the membranous labyrinth, the perilymph, and the solid structures which

invest it are formed from the mesoblast. The otic vesicle sends a process inwards which becomes the *scala media* of the cochlea, which again becomes separated off by a constriction (the future *ductus cochlearis*) from the rest of the vesicle. From other parts of the otic vesicle three rounded protuberances grow out, each of which becomes first flattened and then absorbed, except at its circumference—the three protuberances thus becoming the three *semicircular canals*. Two constrictions then show themselves in the wall of the large part of the otic vesicle, thus separating the *saccule* from the part adjacent to the semicircular canals which becomes the *utricle*.

The *auditory nerve* is formed by direct transformation of the mesoblast in contiguity with the otic vesicle. It is at first distinct and separate both from that vesicle and from the hind-brain, though it grows each way, and becomes connected with both.

The cartilage which forms the *auditory capsule* (investing the otic vesicle) is continuous with that of the basi-occipital region —the parachordal cartilage. This capsule becomes ossified from three centres, the pro-otic, opisthotic, and epiotic bones, as before described. These ossifications leave open two small apertures, one in the outer wall of the cochlea, and surrounded by the opisthotic bone—the *fenestra rotunda*—the other placed more inferiorly, opposite the vestibule, it being bounded above by the pro-otic, and below by the opisthotic—the *fenestra ovalis*.

The external meatus, tympanum, and Eustachian tube are formed, as has been elsewhere said, by differentiation of the first visceral cleft, while the auditory ossicles are formed as has been already related.

The sides and floor of the tympanum, and ultimately the floor of the external auditory meatus, become ossified as the tympanic bones.

From the margin of the second, or hyoidean, visceral arch, a membrane grows out which becomes the external ear.

The DEVELOPMENT OF THE NOSE resembles that of the eye, inasmuch as an involution of epiblast, the *primitive nasal sac*, is related to an outgrowth of brain-substance, the *olfactory lobe* of the cerebrum. Each of the nasal sacs deepens by outgrowth of its free margin, but an inequality in the growth of that margin gradually transforms it from a conical pit open forwards, into a groove or canal leading backwards and inwards. Meantime the maxillary process grows forwards and joins the naso-frontal process, thus bounding the nasal sac below; while the external lateral nasal process bounds it behind—intervening, as it does, between the nasal sac and the eye. Thus the nasal sac comes to open behind into the front of the buccal cavity, but ultimately (as has been already described) the development (by lateral transverse growths) of the palate prolongs the nasal canals backwards and so causes them to open into the hinder part of the mouth. While this growth is going on, the ethmo-vomerine cartilage (formed by the anteriorly coalesced trabeculæ) grows down and embraces the nasal sacs, sending down three cartilaginous processes, one between and one on each side of them. The lateral

cartilages develop processes which extend inwards, and lay the foundations of the maxillo-turbinal bones. In the descending plates of the ethmo-vomerine cartilage, the *median* and *lateral ethmoid* bones become developed.

§ **18**. Thus all the various parts and organs of the adult animal are gradually developed. But it is only by degrees that the fully mature form is attained, the proportions of the head, limbs, and tail of the kitten being obviously different from those of the full-grown cat. Still the young animal is substantially similar to the old, even in appearance, for, though blind, it is covered at birth with a hairy coat, more or less resembling that of one or other of its parents.

But although the young one at birth is evidently a young cat, the process by which the substance of the fertilised ovum has grown into a kitten is a wonderfully circuitous one. For a certain time the embryo cannot be said to bear any resemblance to its ultimate form, while for a considerable period that resemblance is but a very general and obscure one. Even the various organs, such as the brain, heart, &c., are, when first formed, not the brain, heart, &c., of a cat, nor does the course taken by the primitive blood-vessels correspond with that of the blood-vessels of the adult. These transitory conditions have, however (strange as it may appear to any reader as yet unfamiliar with such subjects) resemblances and analogies with structural conditions which are permanent in quite other creatures—in animals, that is, very different both in appearance and nature from the cat.

This curious fact is one of great significance, and it is one of much utility to us. Its utility we shall appreciate when we consider what is the cat's place in nature—a question which the phenomena of its development will help us to determine. The full significance, however, of the developmental process will only appear when, at the end of our inquiry, we apply ourselves to the consideration of the problem of the cat's pedigree and origin.

CHAPTER XI.

THE PSYCHOLOGY OF THE CAT.

§ 1. THE word "Psychology" has been so much used of late to note mental states only, that most readers will probably deem that the phrase "the psychology of the cat," the phenomena of the mind—its feelings, imaginations, emotions, and instincts—are exclusively referred to.

These indeed will all be treated of in this chapter, but "Psychology," according to its original conception, and according to the best rational signification which can be given to the term, has a very much wider meaning; for it denotes the study of all the activities, both simultaneous and successive, which any living nature may exhibit.

On account of the very peculiar nature of a certain number of these—namely, all those which may be classed as "feelings" in the widest sense of that word—it is practically impossible to study them as they exist in any animal without some reference to our own mental activities. The study of such activities as they take place in ourselves, may be followed up in three modes:—

(1.) By introspection, *i.e.*, by the study of our own mental states, through our powers of reflection.

(2.) By the study of our fellow-men as they live and act (in health and in disease), drawing inferences from their words and gestures as to the similarity between their feelings, emotions and perceptions, and our own.

(3.) By examining facts of structure—anatomical conditions—in order to investigate the relations which may exist between different mental phenomena and corresponding (normal or pathological) bodily conditions.

Such of our activities—such phenomena—as we know and can know only by introspection, are called "*subjective*," and they are administered to by the nervous system. That same system, however, also ministers, as we have seen, to many other activities of which introspection can give us no account, since they lie so deep that they are beyond its ken.

Now it is these subjective phenomena, or, at the most, these together with the other activities to which the nervous system

ministers, which are now ordinarily referred to by the term Psychology. Therefore it will be well, in studying the psychology of the cat, to begin with such of its activities as may seem most to resemble, and run parallel to, those human phenomena which are known to us by introspection, together with such others as may be most nearly allied to, or more or less inextricably mixed up with them.

§ 2. We cannot of course, without becoming cats, perfectly understand the cat-mind. Yet common sense abundantly suffices to assure us that it really has certain affinities to our own. Indeed, the cat seems to be a much more intelligent animal than is often supposed. That it has very distinct feelings of pleasure or pain, and keen special senses, will probably be disputed by no one. Its sense of touch is very delicate; its eyes are highly organized, and can serve it almost in the dark, and its hearing is extremely acute. It is obvious also that external and internal sensations—more or less similar to those external and internal sensations of ours by which we instinctively move from place to place, judge of distance and direction, and perceive resistance and pressure—must be possessed by the cat also. Were it otherwise, trees could not be readily ascended in search of birds, leaps could not be accurately taken and mice caught, walls could not be ascended and descended by dexterous combinations of vigorous yet delicately adjusted springs and graplings, nor could small apertures be skilfully passed through in the admirable way in which all these complexly co-ordinated movements are effected by the animal in question. The ease and grace of motion in the cat, and its neat dexterity, are a common subject of praise. Who has not observed how cleverly a cat will avoid objects in its path—walking, perhaps, over a table set with glasses and ornaments in not very stable equilibrium, without overthrowing any one of them. Every one knows also the great facility with which the cat so turns in falling as almost always to alight safely upon its feet. The animal's ordinary locomotion is a walk or a spring. It rarely runs, save when it is pursued or alarmed, and then it progresses by a series of bounds. When driven to it, it can swim, though it takes to the water, or even endures a mere wetting, with the greatest reluctance. Yet a cat has been seen voluntarily to enter a small stream several times, in order to rescue its kittens which had fallen into it.

But the cat has not only external and internal sensations: the facts just referred to cannot be explained without also granting that it has memory, imagination, a power of sensible perception, and of associating images in complex mental pictures which are more or less associated with pleasurable or painful feelings—for unless a cat perceived objects, it could not climb, jump, or pursue its prey. Nor can we doubt, when the presence of a mouse causes the impression of a patch of colour with a definite, familiar outline, on the retina of an experienced cat, that immediately there is a revival of faint antecedent similar impressions, with relations of various kinds, and

pleasurable feelings (also faintly revived) of past catchings, killings, tastings, and eatings. Moreover, when we recollect how common it is for sleeping dogs to show by slight yelps that they are dreaming, we must surely admit that it is probable that cats can likewise dream. Nor is it impossible that when cosily sitting before a cheerful hearth, enjoying the heat they love so well, they may indulge in waking "day-dreams" also.

As to memory, every one knows how cats attach themselves to their homes, and how generally they recognize at least one or two of the habitual inmates of their dwelling place. Everyone knows also how a cat, accustomed to have a saucer of milk at tea-time, will habitually run into the drawing-room with the servant carrying the tea-tray. But even the preparatory clatter of the cups and plates downstairs is often enough to arouse its sensibilities, and put it on the *qui vive*. All this cannot be explained without allowing that the cat-mind can associate complex sets of sensuous impressions of different kinds—pleasurable or painful feelings being, as it were, the cement which binds together such complex associations. Once let a cat be much hurt by anyone, and it will soon show how it has associated a painful feeling with his image.

But cats can so associate sensations and the images of objects in various relations as to draw practical inferences. My friend, Mr. J. J. Weir, tells me of a cat which, having been chased by boys, ran towards a door, jumped up, put one paw through the handle, and with the other raised the latch, thus causing the door to open and enable it to escape. This action he saw several times repeated. Mr. Harrison Weir has also assured me that he has seen a cat unfasten a latch and then open the door it fastened, by pressing its feet against the door-post. He has also had a cat that knocked at a door with the knocker—these acts being untaught, and due only to the cat's spontaneous acts of cognition. I have also heard of a cat which habitually jumped down from a staircase in such a way as in its descent to press with its paws obliquely on the handle of a door and so open it. My friend Captain Noble, of Maresfield, informs me that he has himself known a cat which was in the habit of catching starlings by getting on to a cow's back and waiting till the cow happened to approach the birds, which little suspected what the approaching inoffensive beast bore crouching upon it. He assures me he has himself witnessed this elaborate trick, by means of which the cat managed to catch starlings which otherwise it could never have got near. Many cats will readily learn the signification of certain words, and will answer to their names and come when called. Very strange is the power which cats may show of finding their way home by routes which they have never before traversed. We cannot explain this (as it has been sought to explain the like power in dogs), by the power of smell being the predominate sense, so that a passed succession of smells can be retraversed in reverse order, as a number of places seen in succession on a journey may be retraversed in reverse order by ourselves. On

the whole, it seems probable that the power in question may be du to a highly developed "sense of direction," like that which enable some men so much to excel others in finding their way about citie or that which enables the inhabitants of Siberia to find their wa through woods or over hummocky ice, and who, though constantl changing the direction they immediately pursue, yet keep the main direction unchanged.

In addition to all these cognitions of objects, and of the relatio between them, cats possess strong passions and, often at leas affectionate feelings of personal attachment.

The strength of their sexual feelings is notorious, and hardly le so is the devotion of the mother cat to her young. This latt emotion endures as long as she gives suck, and often, if a cat second litter of kittens be destroyed while one of the previous litt remains, the latter will be again taken into favour, and, resumin its old mode of nourishment, have all the tenderness and affectio shown to it which was manifested towards it at first. Cats wi sometimes (as before mentioned) show great regard to individual and will manifest it by expressive gestures and slight, affectionat bites. These animals, then, have *emotions*, and they are able t express their feelings by external signs. Some observers hav professed to detect more than half a hundred different expressio in a cat's face, but however much exaggeration there may be i such a statement, it is impossible to mistake their gestures of rag and fear at the sight of a strange and threatening dog—gestur well understood by the dog, and sufficient in most cases to keep hi at a safe distance.

But it is not only by gestures that cats express their feeling Besides their hideous nocturnal howls, cats give expression to the desires by gentle sounds. Almost everyone must have met with cat which by mewing expressed its wish for a door to be opened, which thus begged for a little milk. Cats then have a language their own, made up of sounds and gestures.

Cats also have a will of their own, as all must know who hav tried to retain on the lap, a cat minded to go elsewhere, or who hav observed the determination with which they pursue the objects their desires.

Manifestations of quite another kind from these quasi-intellectu ones are, however, also shown by cats. For they possess tr *instincts*,* and blindly follow innate promptings in pursuit of ends

* One of the to us unpleasing instincts of the cat is that which prompts it to play with the captured mouse instead of killing it, the object and meaning of which have been regarded as inexplicable. My friend Professor Paley has made the following suggestion as to the true utility and meaning of this instinct. He writes :—"When we observe carefully the motions of a kitten in playing with a ball or a cork and a string, we shall see that they are suggested by the ve same instincts which are exerted by cat in playing with a disabled mou In both there is the withdrawal and t sudden pounce, and also the propelli the motionless object with the cla It is a mistake to suppose that a kitt is actuated solely by a love of sporti play. Those who speculate on the la which allow the existence of human a animal suffering, alike, profess the

which they can have no cognition whatever. This is shown by both parent and offspring at birth. The young spontaneously seek, find, and suck from, the mother's teats, while the young mother, also yielding to the spontaneous promptings of her organization, unhesitatingly gnaws thorough the umbilical cord of her first kitten.

So also a kitten brought up without any experience of mice, will pursue with eagerness, catch and kill the very first mouse which comes in its way. These instinctive acts are acts which spring necessarily from the structure of any organism, much as the actions of a steam-engine must follow their designed course when heat and water are duly supplied. Not, of course, that they are altogether such: for the steam-engine is a mere machine, while the animal is a living organism, endowed with much plasticity of body, and (as we have seen) even with a power of drawing practical inferences. Its instinct is, therefore, necessarily somewhat, as it were, plastic also, and capable, within limits, of accommodating itself to changed circumstances.

Instinct, then, is a power of a kind distinct, on the one hand, from even such intelligence as cats* have, and distinct from mere reflex action on the other.† Attempts have been made to deny its existence and distinctness,‡ but they have only served to make them the more manifest.

selves shocked at what they call the "unnecessary cruelty" of the cat. It is worth while therefore to inquire if there is not a reason that can be given for it in the economy of nature. For to do this is better than to view the circumstance as one of the proofs of imperfection in that economy. When we consider that the prey of the feline race is usually nimble, and that it can only be caught by a pounce upon it, we shall see that success in catching mice, birds, &c., must depend on *constant practice*. The creature escapes and is recaught again and again, and always by a pounce. To make real escape impossible, the victim is nipped or disabled, but generally so slightly that it may at first be taken from the cat very little injured. It is clear that each capture is thus made a lesson in catching. For everything depends on the sudden and noiseless dash."

* Mr. Douglas A. Spalding found kittens to be imbued with an instinctive horror of the dog before they were able to see it. He tells us:—"One day last month, after fondling my dog, I put my hand into a basket containing four blind kittens, three days old. The smell my hand had carried with it set them puffing and spitting in the most comical fashion." (Nature, October 7, 1875, p. 507.)

† "Instinct, *as* instinct, is of course an abstraction existing in the mind, though it exists concretely enough in animal actions of a special kind. Instinct is, concretely, the animal organism energizing in certain ways." "It is a faculty of the feeling, imagining, organically-remembering and automatically-acting soul, which faculty is in most intimate connection with the organization of each species, so that upon the recurrence of certain sensations, external or internal, a definite series of actions is initiated, for the performance of which the organization has been specially developed. It is action like reflex action, save that it takes place in consequence of feelings and imaginations. It is so intimately related to an animal's structure, that if it were possible for us to construct any given kind of animal, we should necessarily give rise to the instinct in giving rise to the structure.' (Lessons from Nature, pp. 236 and 239.)

‡ Mr. Herbert Spencer and the late Mr. Lewes agree in entertaining very singular views as to instinct. According to Mr. Spencer, it is a higher development of reason, which it has replaced owing to the establishment of a more perfect adjustment of inner relations to outer relations than exists where mere reason is concerned. Mr. Lewes regards

Much below instinct are those activities before referred to as due to reflex action, and which exist in the cat as well as in ourselves, but which cannot take place without an innate power of being impressed and affected by stimuli which are not felt.

Altogether then, THE CAT'S ACTIVE POWERS may be summed up as follows:—

1. Vegetative powers of growth and reproduction.
2. A power of locomotion and of motion of various parts of the body.
3. A power of being impressed by unfelt stimuli.
4. A power of responding to such impressions by appropriate movements—*reflex action.*
5. A power of responding to felt stimuli by simple actions, plainly involuntary—*excito-motor action.*
6. A power of blindly performing appropriate complex acts, by seemingly voluntary, actions in response to felt stimuli—*instinct.*
7. A power of experiencing pleasure and pain.
8. A power of experiencing vivid feelings from material objects—*sensation.*
9. A power of reproducing by mental images past feelings in a faint manner.
10. A power of associating such images with fresh sensations according to the different relations in which they have co-existed—*sense perception.*
11. A power of associating images in groups—*imagination.*

it as "lapsed intelligence," brought about by the "logic of feeling." That there *is* a logic of feeling—that there is a logic in even insentient nature—is not to be denied; but that logic is not the logic of the crystal, not of the brute, but of their CREATOR. Dr. Bastian, in his recent work (The Brain as an Organ of Mind, p. 221), also endeavours to show that instinct is not a special faculty. But all these writers avoid considering the real difficulties which oppose their views in either direction. Thus Mr. Spencer shirks all consideration of the phenomena which his hypothesis fails to explain—such as the instincts of the wasp *Sphex* and of the carpenter bee. Dr. Bastian does the same; contenting himself by gratuitously asserting as to ants and bees (*l. c.*, p. 235): "There can be little doubt, that if our means of knowledge were greater than it is, we should be able to explain these and all other instincts by reference to the doctrines of 'inherited acquisition' and 'natural selection,' either simply or in combination." At the other end of the mental scale, all the highest phenomena are also simply ignored by all these writers alike. Nothing is said by one of them as to our apprehension of Being, truth, or goodness. The much to be lamented death of Mr. Lewes cut short his work abruptly, so that it may be, had he lived, he would have addressed himself to the problem; but it is strange that neither Mr. Spencer nor Dr. Bastian should have attempted to grapple with it. Without so doing, all their conclusions may be simply disregarded, as the phenomena they notice are all beside the main issue they profess to raise. As to instinct, Dr. Bastian seeks to explain it by reference to the evolution of contractile hearts, oviducts, and intestines. But does he mean to imply that these contractions were in their first origin deliberate and voluntary? Was the original "desire for food" a desire which a creature deliberately chose to have, or was it developed by "natural selection," those organisms that had no desire for food becoming extinct? But how could natural selection ever originate a desire for food? To what could it have been due but to an IMPLANTED IMPULSE; and if such an impulse must be acknowledged at all, why not acknowledge it with respect to instinct, the facts as to which so emphatically demand its recognition?

A power of agglutinating and combining imaginations and sense-perceptions in clusters, and clusters of clusters, so forming more and more complex imaginations—*sensuous association.*

A power of *memory.*

A power of so reviving complex imaginations, upon the occurrence of sensations and images, as to draw practical consequences—*organic inference.*

Powers leading to spontaneous impulsions in different directions through internal or external stimuli—*appetites.*

Powers of pleasurable or painful excitement on the occurrence of sense-perceptions with imaginations—*emotions.*

A power of expressing feelings by sounds or gestures, which may affect other individuals—*emotional language.*

A power of spontaneous activity in response to sensations or emotions—*organic volition.*

. In the possession of all these varied powers, we and the cat milar. But in spite of this resemblance, common sense and assure us that there is a profound difference between the of man and the highest psychical powers of the cat. This ence is made plain and obvious to our senses by the fact that n talk, while neither the cat nor any other beast or bird has ft of SPEECH.

may, perhaps, be objected that it was just before declared that at *has* language. Now, no mistake can well be greater than of confounding together two things essentially different on nt of some superficial resemblance which may exist between : to call bats, birds, or whales, fishes, would be error of this

e cat has a language of sounds and gestures to express its feel- and emotions. So have we. But we have further, what r the cat nor any other beast or bird has—a language of s and gestures to express our THOUGHTS! I do not refer to *late* sounds. Rational language can exist without oral speech, rticulate sounds may be uttered (as by parrots and certain though reason be absent. Articulate speech (or the *oral* is but one mode (though much the most convenient mode) of g known the far more important and significant thought (or *l word*). It is the *latter* which generates the former, as we ain and again in each new branch of science or art, wherein onceptions having been evolved, new words are coined to give ssion to them. Men do not invent new articulate sounds first, ttach meanings to them afterwards, but the very reverse.*

. Bastian, in the work lately to, has a short chapter entitled, Brute to Human Intelligence," ch he considers the question of ge, with the intention of showing ere is only a difference of degree n the mind of man and that of a But he not only quite fails to show how the human intellect could have originated, but even gives up his own contention by speaking (p. 415) of human language as having been "started by some hidden and unknown process of natural development, or as a still more occult God-sent gift to man."

Great ambiguity and confusion exist as to LANGUAGE, six kinds of which may be distinguished:—

(1) Sounds which are neither articulate nor rational, such as cries of pain, or the murmur of a mother to her infant.

(2) Sounds which are articulate but not rational, such as the talk of parrots, or of certain idiots, who will repeat, without comprehending, every phrase they hear.

(3) Sounds which are rational but not articulate, such as the inarticulate ejaculations by which we sometimes express assent to, or dissent from, given propositions.

(4) Sounds which are both rational and articulate, constituting true "speech."

(5) Gestures which do not answer to rational conceptions, but are merely the manifestations of emotions and feelings.

(6) Gestures which do answer to rational conceptions, and are therefore "external," but not "oral," manifestations of the *mental word*. Such are many of the gestures of deaf mutes, who, being incapable of articulating words, have invented or acquired a language of gesture.

§ **4.** But that the true nature of the cat-mind may be the better appreciated, it is desirable to recognize distinctly what are those HUMAN MENTAL POWERS, of the possession of which by the cat no evidence exists. They are the following ones:—

(1) A power of apprehending abstract ideas gathered from concrete objects, such as the ideas, being, substance, unity, truth, cause, humanity, etc.—*abstraction*.

(2) A power of apprehending external objects *as* such, and recognizing that they *exist in truth—intellectual perception*.

(3) A power of directly perceiving our own *existence—self-consciousness*.

(4) A power of turning the mind back upon what has been directly apprehended—*reflexion*.

(5) A power of actively searching for, and so recalling past thoughts or experiences—*intellectual memory*.

(6) A power of uniting our intellectual apprehensions into an explicit affirmation or negation—*judgment*.

(7) A power of combining ideas, and so giving rise to the perception of new truths thus arrived at—*intellectual synthesis and induction*.

(8) A power of mentally dissecting ideas, and so gaining other new truths, and also of apprehending truths as necessarily involved in judgments previously made—*intellectual analysis, deduction and ratiocination*.

(9) A power of apprehending some truths as absolutely, positively and universally necessary—*intellectual intuition*.

(10) Powers of pleasurable or painful excitement on the occurrence of intellectual apprehensions—*higher, or intellectual emotions*.

(11) A power of giving expression to our ideas by external bodily signs—*rational language*.

power of, on certain occasions, deliberately electing to act or to abstain from acting) either with, or in opposition to, he resultant of involuntary attractions and repulsions—*will*.

all the actions performed by the cat—all of which may be under one or other of the eighteen groups of the former * list ties—are such as may be understood to take place without tion or self-consciousness. For such action it is necessary, that the animal should sensibly cognize external things, but necessary that it should intellectually perceive their being; hould feel itself existing, but not recognize that existence; hould feel relations between objects, but not that it should nd them as relations; that it should remember, but not ually seek to recollect; that it should feel and express s, but not itself advert to them; that it should seek the ble, but not that it should make the pleasurable its deliberate

ct, all the mental phenomena displayed by the cat, are of explanation by the former list of psychical powers, with- aid of any one of those enumerated in the above catalogue rational faculties,† nor could any of the former by any mere

second section of this chapter,

iend of mine, Professor Clarke, t :—"In ourselves sensations et the intellect to work; but that they do so in the dog is question that the dog has an A cat to bestir itself to obtain after dinner, need not enter- *belief* that the clattering of n they are washed is usually ed by the presence of food for t to secure its share it must tain movements; for quite tly of such belief, and by mere association, the simple conjunction of the previous novements, and consequent of taste, would suffice to set me movements on the present Let certain sensations and s become associated, and then need not be noted: they only ist for the association to pro- effects, and stimulate appre- deliberation, inference, and "When the circumstances of t case differ from those of any ence, but imperfectly resemble any past experiences, parts of consequent actions, are irregu- ested by the laws of resem- til some action is hit on which in or gives pleasure. For . . . let a dog be lost by his a field in which *he has never* been before. The presence of the group of sensations which we know to indicate his mistress is associated with pleasure, and its absence with pain. By past experience an association has been formed between this feeling of pain and such movements of the head as tend to recover some part of that group, its recovery being again associated with movements which, *de facto*, diminish the distance between the dog and his mistress. The dog, therefore, pricks up his ears, raises his head and looks round. His mistress is nowhere to be seen; but at the corner of the field there is visible a gate at the end of a lane which resembles a lane in which she has been used to walk. A phantasm (or image) of that other lane, and of his mistress walking there, presents itself to the imagination of the dog; he runs to the present lane, but on getting into it she is not there. From the lane, however, he can see a tree at the other side of which she was wont to sit; the same process is repeated, but she is not to be found. Having arrived at the tree, he thence finds his way home." By the action of such feelings, imaginations, and associations—which we know to be *veræ causæ*—I believe all the apparently intelligent actions of animals may be explained without the need of calling in the help of a power, the existence of which is inconsistent with the mass, as a whole, of the phenomena they exhibit.

increase of intensity, change into one of the latter, for they differ not in degree, but in *kind*.

Into this question, however, it is not desirable, for the object of this work, further to enter. It is the less necessary so to do, because the subject has been treated at length in a book which may be regarded as introductory to the Author's present work. I refer to "Lessons from Nature as manifested in Mind and Matter," and especially to its 4th, 5th, 6th, and 7th chapters, in which the distinctions of kind which exist between the mental powers of man and the analogous powers of brutes are considered in detail.

§ **5.** Such then, in the judgment of the present writer, are the most significant facts and the most important deductions with respect to the cat's psychology in the commonly used meaning of that word. But, as has been here observed more than once, the term "Psychology" has and should have a much wider meaning, and embrace all the vital activities, of whatsoever kind, of which any animal is capable.

These activities are of very different orders. Some of them are manifestly (like those of locomotion) activities of the entire creature. Others (like the activities of digestion or respiration) involve a large portion of the animal's body; while others again (such as those which result in the formation of a nerve-cell or a blood-corpuscle) are activities which are confined to only very minute portions of its frame.

Yet the whole of these activities must proceed harmoniously, or the animal could not continue to live in health and strength. Its body is obviously a unity. The activities of that body are in some way CO-ORDINATED and UNIFIED also. To understand this fully, is truly to understand Psychology.

§ **6.** In the foregoing chapters we have considered both the several parts of which the cat's body is made up, and also the functions which they severally and collectively perform. We have also noted the successive modifications and transformations which take place during development—*i.e.*, those series of forms which are assumed by the developing animal, between the condition of the unimpregnated ovum and that of the adult cat.

We have seen (1) in the first place that the cat's body is made up of a collection of "systems" of organs, such as the nervous system, the muscular system, and the alimentary, circulating, respiratory, and generative systems; (2) secondly, we have seen that each such system is made up of a number of "organs," which act together in harmony. Thus we have seen, *e.g.*, that the nervous system consists of a brain, a spinal cord, sympathetic ganglia, and various sets of nerves, some of these nerves energizing by the help of special parts, called "sense-organs"—the functions of the whole being some form of *sensitivity*. Again, the alimentary system we have seen to consist of a mouth with jaws, tongue and teeth, of an œsophagus, a stomach and an intestine with accessory glandular structures—the function of the whole being to minister to *alimenta-*

tion. So also we have seen that the cat's circulating, respiratory, and generative systems of parts, have each their special function, in the performance of which their various constituent organs harmoniously concur. (3) Thirdly, we have seen that each "organ" is made up of a greater or less number of "tissues," which together enable it to perform that function for which it is destined. Thus the stomach consists of a basis of fibrous tissue, with much muscular tissue, and is coated internally with epithelium, which, descending into superficial depressions lines the various glands which open upon its surface. It is also richly supplied with vessels and nerves. Its fibrous tissue maintains its shape and gives it the strength requisite for its continued existence. Its muscular tissue is the source of its motor power, without which it could not physically act, and its epithelial lining, endowed with its secreting properties, is the source of its digestive power, without which it could not act chemically on the food contained within it. Its vascular structure affords the nutriment which its several parts need to repair the waste of its continued action (which action, without this supply, would soon come to an end), and its nervous tissue, with its property of "impressionability," is the regulating agent which adjusts the actions of the other tissues and of the entire viscus as one whole. (4) Fourth and lastly, we have seen that each separate tissue is composed of its own ultimate parts—different in each tissue, but which may, in all cases, be said to consist of a matrix—fluid or solid, fibrous or homogeneous—with corpuscles, which are cells modified in one or another mode. We have also seen that each tissue is at first cellular, and is derived in one or another way from two layers of cells—epiblast and hypoblast—themselves the product of the spontaneous divisions of the germ-cell. Each of these cells, therefore, possesses, for a longer or shorter time, its own activity and plays its own part in contributing to the general property of that tissue of which it forms a minute portion. Thus we have:

(*a.*) *Cell activities*, contributing to that special vital property which is characteristic of each tissue.

(*b.*) *Tissue activities*, contributing to that special function which is characteristic of each organ.

(*c.*) *Organ activities*, contributing to that more complex function which is characteristic of each system of organs, viewed as one complex whole.

(*d.*) *System activities*, consisting of the combined activities of sets, or systems, of organs, and contributing to a higher and yet more complex function.

§ 7. For just as cell activities are subsumed by that of the tissue they compose, and as the vital properties of tissues are synthesized into a higher unity by the organ of which they form a part, and as the functions of organs are embraced by the higher function of that system of parts of which such organs are members, so are the functions of all the systems of organs subsumed and synthesized into a yet higher unity, *which is* the life of the animal itself, and which

life is the function of its body considered as one whole, just as the subordinate functions are those of that body's several sets of organs.

That the living cat is one creature in feeling and action, as well as that its body is one—*i.e.*, that it is a unity dynamically as well as statically—is what common sense and reason unite to assure us. These suffice to convince us that the plaintive cries of its victim, the sight of its struggling form, and the taste of its blood, may be all simultaneously felt by the same cat. More than this: such sensations call up more or less distinct reminiscences of similar feelings before experienced, and give rise to vivid emotions and appropriate actions, so that past and present sensations, of very varied kinds, are united with different emotions and appropriate actions in one existing psychical activity. Such an animal then is really the theatre of some unifying power which synthesizes its varied activities, dominates its forces, and is a PRINCIPLE OF INDIVIDUATION. There would seem to be here present, a vital force or principle, which has no organ except that of the entire body within which it resides, and the activities of which reveal that principle's existence, just as the contractions of muscular tissue make known to us its intrinsic, and otherwise imperceptible, power of contractility.

§ **8.** But it may be thought that in the nervous system we have the organ and vehicle of such unifying activity. Undoubtedly the nervous system is, as before said, the great regulator of the body's activities. But its *own* action requires regulation, and to be adjusted to the actions of other systems. It cannot, however, regulate itself. Moreover, all the vital activities needed for growth, sustentation and reproduction, may exist in the greatest abundance without any trace of a nervous system, as in the great world of plants—some of which, such as the well-known sun-dew (*Drosera*) and Venus's fly-trap (*Dionæa*), very curiously simulate the actions of animals. In such plants we evidently have susceptibilities to impressions of a complex kind; for impressions made by objects, such as insects, are followed by singularly appropriate actions on the part of the plants to secure and digest their living prey. Very curious too are those movements by which the roots of some plants seek moisture as if by instinct,* or those by which the tendrils of certain climbers appear to search for some fitting support, and, having found it, to cling to it by what resembles a voluntary clasping.† Still more remarkable is the way

* My friend Professor Paley, tells me that in 1863 at Penn, near Wolverhampton, a sycamore tree of considerable size was found to have sent down into a well, to reach the water, a root forty-four feet long, and about a quarter of an inch in diameter throughout. A mass of roots had wrapped themselves round the upper part of the well and nearly stopped it up. The Rev. F. H. Paley (formerly vicar of Penn, and now vicar of Church Preen, Shrewsbury) has confirmed the truth of this statement.

† These tendrils oscillate till they touch an object, which they then embrace. The tendril of a passion-flower may sometimes be made to bend by the pressure on it of a thread weighing no more than the thirty-second part of a grain, or by merely touching it for a time with a twig. If, however, the twig be taken away again at once, the tendril will then soon straighten itself. Yet neither the contact of other tendrils of the same plant or the fall of raindrops will produce such bendings.

in which the little creeping plant, the "mother of a thousand" (*Linaria*), explores the surface of a wall to find an appropriate hollow for her progeny, which hollow being found, her capsule is plunged in it, and its seed is there discharged. Here, therefore, there a co ordination of actions for the benefit of the whole organism, and yet in no plant is there a trace of a nervous system.

§ 9. The existence in each animal of an internal principle of individuation and co-ordination is indicated by various ANATOMICAL AND PATHOLOGICAL FACTS. We have seen the bilateral and serial symmetry which exists in the cat's body and limbs. Relations of symmetry of similar kinds show themselves also in abnormal and diseased conditions. Sir James Paget,* in treating of symmetrical diseases, mentions a lion's pelvis which was marked, through a sort of rheumatic affection, by a pattern more complex and irregular than the spots upon a map, yet so symmetrically disposed that all spots or lines on one side of the pelvis were exactly repeated by those on the other side. He also observes that diseases very often affect simultaneously such homologous parts as the backs of the hands and feet, the palms of the hands and the soles of the feet, the elbows and knees, and the corresponding parts of the upper arms and thighs.

As to monstrosities, M. Isidore Geoffroy St. Hilaire remarks:* "L'anomalie se répète d'un membre thoracique au membre abdominal du même côté," and quotes a case in which certain corresponding parts of the carpus and tarsus, the metacarpus and metatarsus and of the digits, were simultaneously absent.

Professor Burt G. Wilder has recorded† no less than twenty-four cases where such excess co-existed as regards both little fingers; six in which both little fingers and toes were similarly affected, and twenty-two cases more or less the same, but in which the details were not accurately to be obtained.

Perhaps, however, the most curious and instructive cases are those presented by some of our domestic birds. In trumpeter pigeons, and some bantams, the feet, which are usually naked, become abnormally feathered, and these feathers may even exceed in length those of the wings. They are also developed from that side of the foot which corresponds with the feather-bearing side of the hand. Moreover, in ordinary pigeons, though the digits of the hand are completely united together, the toes of the foot are free. In these abnormal pigeons, however, the outer toes become more or less united together by skin like the fingers.

Facts such as these, seem to make evident the existence in each animal, which as a whole is a visible unity, of an innate polar force tending to carry out development in definite directions, but liable to have its effects modified by the action of surrounding circumstances.

* Lectures on Surgical Pathology, 1853, vol. i., p. 18.

† Hist. *Générale des Anomalies*, t. i., p. 228. Bruxelles, 1837.

‡ Massachusetts Medical Society, vol. ii., No. 3, June 2, 1868.

All such animals however, as those just mentioned, have a well developed nervous system; but there are other animals in which symmetry of form is carried to the highest degree, while yet no trace of a nervous system is to be detected in them.

Such creatures are the Radiolarians—minute marine organisms of

Fig. 163.—DORATASPIS POLYANASTRA. ADULT

almost the simplest structure as regards their soft substance, but which have siliceous skeletons of extreme complexity and beauty, and, at the same time, of marvellous symmetry.

§ **10**. In such an animal as the cat, then, we have indeed evidence of a principle of individuation; for in it we have not only symmetry of organization and harmonious organic action (as in the lowly organized creatures just referred to), but also sense perceptions which meet in a central sensitive faculty able to discriminate the odorous from the coloured and the sapid from the audible.

Not that there is any reason to think that the cat can appreciate the odours, &c., *as such*, but only that it is practically impressed by the relations and distinctions between its own sensations as well as between the objects which elicit them. It has, in fact, not consciousness but "CONSENTIENCE."

§ **11**. But, as we have seen, its nervous system ministers to a vast number of actions which are unfelt as well as to its felt actions, while its life is also made up of actions which the nervous system

cannot control. Such are the actions within the nervous system itself, and the changes which take place in the ultimate substance of the other tissues beyond the reach of the finest vessels or the most delicate nerves.

Some actions (such as those above referred to) we *know*, by our own experience, are "felt" actions—the "subjective" and immaterial phenomenon taking place simultaneously with the bodily change. But no physiologist can deny but that other nerve actions,

Fig. 164.—DORATASPIS POLYANASTRA, YOUNG. SHOWING ITS MULTIPOLAR MODE OF GROWTH. THE SPHERICAL SHELLS ARE FORMED BY OUTGROWTHS, WHICH SPRING FROM THE RADIATING PARTS AT SIMILAR DISTANCES FROM THE CENTRE OF THE SHELL. THE LATERAL EXTENSIONS FROM THE RADII MEETING TO FORM A SPHERE BY THEIR JUNCTIONS.

which are not felt, may have their quasi-subjective or immaterial sides also. More than this: to be rational, we must admit that every action of any animal really has its quasi-subjective or immaterial side. Mr. Bain has said,* "It would be incompatible with everything we know of cerebral action, to suppose that the physical chain [of phenomena] ends abruptly in a physical void, occupied by an immaterial substance; which immaterial substance, after working alone, imparts its results to the other edge of the physical break, and determines the active response—two shores of the material, with an intervening ocean of the immaterial." This is good as far as it goes, but the converse is at the least as inconceivable—namely, a break in the immaterial chain, bridged over by the intervention of a physical substance. Moreover, what Bain here affirms with respect to the brain and its activity, must, by any logical pyschologist, be also affirmed with respect to every entire living organism and its activity. We find in each organism a chain of physical phenomena

* *Mind and Body*, p. 13.

accompanied by a chain of immaterial energies, some part of which we know in ourselves as conscious feeling and thought; but the rest of which, in ourselves, and in all other living creatures, we can only know by rational inference. The chain of physical phenomena consists of the actions of that side of the one living whole, which we call its visible body. The chain of immaterial energies consists of the actions of that side of the one living whole which is its principle of individuation, its "*psyche*," or "*soul*."

§ **12**. The word "SOUL" must not be understood to denote that which it has been, in modern times, commonly used to express. By it is not meant a substance numerically distinct from the animal's body, and which may be conceived as capable of surviving the destruction of the latter *—a conception which is unphilosophical as well as unscientific.

We have seen that structure and function ever vary together, just as the convexities and concavities of the same curved line do and must vary together. In the same way the "principle of individuation," or "soul," of any animal (and of any plant either), and its material organisation, of which that soul is the "function," must necessarily arise, vary, and be destroyed simultaneously, unless some special character, as in the case of man, leads us to consider it exceptional in nature. The word "soul," then, as here used, and as used by Aristotle and his followers, does not denote a separate entity which inhabits the body—an extra-organic force within the living creature, and acting by and through it, but numerically distinct from it. It denotes that which as considered apart from the body is but a mental abstraction, but which, considered as one with the body, exists most truly and really as an inseparable part of one indivisible whole—the living body. It and the body are one, as the impress on stamped wax and the wax itself are one, though we can ideally distinguish between the two. Our common sense assures us of that which science and philosophy confirm, namely, that a living animal is not a piece of complex matter played on by physical forces from without, which transform themselves in passing through it; but is the expression of a peculiar immanent principle (whensoever and however arising), which for a time manifests its existence by the activities of the body with which it is so entirely one that it may much more truly be said to *be* the animal than the lump of matter which we can see and handle can be said to be such animal.

Thus the real, substantial constituent essence of the animal we are studying—as of every other animal—is not what we see with our eyes; it is something which ever escapes our senses, though its existence and nature reveal themselves to our intellect. It necessarily escapes our senses, because these senses can detect nothing in

* Even in man, there is no adequate reason for believing in the existence of any principle of individuation, save that *which* exerts its energy in all his *functions*, the humblest as well as the most exalted, though there is good evidence of a philosophical kind that in his case that principle does survive the dissolution of the body.

an animal or plant beyond the sensible qualities of its material component parts. But neither is the function of an organ to be detected save in and by the actions of such organ, and yet we do not deny it its function or consider that function to be a mere blending and mixture of the properties of the tissues which compose it. Similarly it would seem to be unreasonable to deny the existence of a living principle of individuation because we can neither see nor feel it, but only infer it. This power or polar force, which is immanent in each living body, or rather which is that body living, is of course unimaginable by us, since we cannot by imagination transcend experience, and since we have no experience of this force, save as a body living and acting in definite ways.

§ 13. It may be objected that its existence cannot be verified. But what *is* verification? We often hear of "verification by sensation," and yet even in such verification the ultimate appeal is not really to the senses, but to the intellect, which may doubt and which criticises and judges the actions and suggestions of the senses and imagination. Though no knowledge is possible for us which is not genetically traceable to sensation, yet the ground of all our developed knowledge is not sensational, but intellectual, and its final justification depends, and *must* depend, not on "feelings," but on "thoughts." "Certainty" does not exist at all in *feelings* any more than doubt. Both belong to thought only. "Feelings" are but the materials of certainty, and though we can be perfectly certain about our feelings, that certainty belongs to thought and to thought only. "Thought," therefore, is our absolute criterion. It is by self-conscious thought only that we know we have any feelings at all. Without thought, indeed, we might feel, but we could not know that we felt or know ourselves as feeling. If then we have *rational* grounds for recognizing the existence of this "soul"—and its existence is made known to us by its *acts*, and is *verified* by our reason—then, the poverty of our powers of imagination should be no bar to its recognition. We are continually employing terms and conceptions—such, *e.g.*, as "being," "substance," "cause," &c.—which are intelligible to the intellect (since they can be discussed), though they transcend the powers of the imagination to picture.

On all sides things made known to us by sense (sensibles), serve to elicit conceptions of things which can be apprehended by the intellect (intelligibles), but can never be themselves directly perceived by the senses. As they cannot be so perceived, they can never be imagined, but can only be symbolically expressed by words or other signs. Such signs must always be inadequate to express what they are intended to symbolise, because we can use no signs which are not transcripts of sense, while what they are intended to symbolise, is, as we have seen, beyond sense. Such symbols, therefore, are necessarily open to the cavils of any one who professes not to have the ideas they serve to express, and who asks for sense-impressions absolutely equivalent to such ideas; since none such can there be. But no objection can hence be drawn against the conception of the

"animal soul," which is not equally valid against all those conceptions, "cause," "being," "substance," &c., without the acceptance of which, our intellectual activity must come to an end altogether.

This principle of individuation, then, this soul, or ψυχή, animates the *whole* body, and presides over *all* its actions; which are, indeed, *its* actions, the body, as a whole, being its "organ"—the function of such "organ" being the "soul's action" or "life." Not to admit this is to be driven to the absurdity of conceiving the living body to be made up of an indefinite quantity of minute independent organisms, without subordination or co-ordination, each with its own principle of individuation, its own soul.* This conception, indeed, but multiplies difficulties, since the same arguments can be brought against each of these souls, or against the one soul, while to affirm their existence and deny functional unity, is to contradict the direct evidence of our senses as regards other organisms, and even the evidence of consciousness itself as regards our own; for each man's own feelings and perceptions declare to him that he is one whole—a living unity in multiplicity.

§ **14.** But some writers who fully recognize the fact of the two co-existing cycles of animal life (the physical and the immaterial) have regarded the latter (the immaterial) as the mere effect of the former (the physical), and have denied to the feelings of animals, or to the thoughts of men, any power to act as causes in the events of life—both animals and men being regarded as mere automata. But the notion that an animal is *really* a machine is an absurdity; for a machine is a complex structure, the actions of which are fully to be accounted for by the physical properties of its component parts and the action of merely physical forces—without the intervention of sensation, or of any influences like those which induce nutrition and reproduction in living creatures. A clock, to be really comparable with an animal, must be capable of winding itself up, gathering oil to replace that which is used up in its movements, repairing any trifling injuries which may result from the friction of its wheels, and finally, of giving forth from time to time miniature reproductions of itself destined ultimately to attain the size of the parent timepiece.

Now an animal such as the cat, is a complex structure which really has all these powers, and its parts are, as we have seen, so mutually adjusted to serve one another, that it may be said to be a mechanism the parts of which are reciprocally ends and means. The nervous system ministers to the circulation, the circulation to the nervous system, and both these to the alimentary system which nourishes them again; and so on throughout the whole complex collection of apparatus which make up the cat's body.

But that body is one which, like a machine, *does* act mechanically and necessarily, because its actions are necessarily determined by the adjustments of its various parts. Yet its actions do not take place without sensations, and these sensations are not the *mere accom-*

* As has been affirmed by Professor Haeckel.

paniments of bodily actions, but are themselves guides and directing agencies which intervene and operate upon, though they do not break through, the circle of its bodily actions. The feeling of the blow of a stick, or the sight of a threatened blow, will change the course of action which a cat would otherwise have pursued. That it is the *feeling* or the sight of the stick, together with the various passed feelings or imaginations which such fresh experience calls up, which causes the change, will be disputed by no one who has not some eccentric thesis to maintain.

But the movements of the animal are also determined (like our own) by a multitude of organic influences which are not felt, though they operate through the nervous system (being thus parallel with those which are felt) and form part of the immaterial chain which accompanies the chain of physical modifications which take place during its life. Thus, again, we see that the animal is a creature of activities which are partly physical and material, partly psychical and immaterial, of which the latter—both the felt and the unfelt—are directive, though they are in turn influenced by physical modifications. We may compare this reciprocal influence to the alterations in the shape of a ring formed of two inseparably united metals which contract unequally at the same temperatures—alterations in either constituent affecting the compound whole, and therefore affecting the other constituent also.

The notion that an animal is a mere automaton in which the physical action alone enters into the chain of causation, has been supported by comparing its psychical activities to mere collateral products of the working of a machine, such as the sound of the steam engine's whistle. Against this, Mr. Lewes has urged* as follows: "The feeling which accompanies or follows a particular movement cannot, indeed, modify *that* movement, since that is already set a going, or has passed; but the analogy fails in the subsequent history: no movements whatever of the steam engine are modified by the whistle which accompanies the working of that engine; yet how the reflected influence modifies the working of the organism! If the hand be passing over a surface, there is, accompanying this movement, a succession of muscular and tactile feelings which may be said to be collateral products. But the feeling which *accompanies* one muscular contraction *is itself the stimulus* of the next contraction; if anywhere during the passage the hand comes on the surface which is wet, or rough, the change in feeling thus produced, although a collateral product of the movement, instantly changes the direction of the hand, suspends or alters its course—that is to say, the *collateral product of one movement becomes a directing factor in the succeeding movement.*" This is what no automaton could effect. Sensation is of the essence of the process, and is evidently a "cause."

What light is thrown upon this subject by our own knowledge of

* Physical Basis of Mind, p. 407.

ourselves? We know that in our own actions sensations enter as *causes* as well as accompaniments of our activity, and not only this, for we know further that our thoughts may also enter into the same circle of our life changes. We know that it is our *knowledge* that a certain event is imminent (*e.g.*, that a storm is fast approaching) which makes us act in a certain way (*e.g.*, to stop in a walk and begin to return towards home) in anticipation of it. To deny this is to deny the evident teaching of our consciousness—it is to deny what is most evident in favour of what is much less so—some speculative hypothesis. Let us suppose that some one tells us when away from home that our house is on fire, who does not *know* that the actions he thereupon performs are due to his mental apprehension of the news told him? If we do not *know* such a thing as this we know *nothing*, and discussion is useless. As the late Mr. Lewes has said,* "That we are conscious, and that our actions are determined by sensations, emotions, and ideas, are facts which may or may not be explained by reference to material conditions, but which no material explanation can render more certain." The advocate of "Natural Selection" may also be asked, "How did knowledge ever come to be, if it is in no way useful to its possessor, if it is utterly without action, and is but a superfluous accompaniment of physical changes which would go on as well without it?"

§ **15.** But let us learn a little more from our own experience of our own nature. We know that a whole multitude of actions, which are at first performed with attention and full consciousness, come at last to be performed unconsciously; we know that effective impressions may be made on our organs of sense without our knowledge—our attention at the time of the occurrence being diverted. We know also that countless organic activities take place in us under the influence and control of the nervous system, which either never rise into consciousness at all, or only do so under abnormal conditions. Yet we cannot but think that those activities are of the same generic nature, whether we feel, perceive, or attend to them or not. The principle of individuation in ourselves, then, evidently acts with intelligence in some actions, with sentience in many actions, but constantly in an unperceived and unfelt manner. Yet we have seen that it undeniably intervenes in the chain of physical causation.

The principle of individuation in the cat is a principle which subsumes into a higher unity, which unifies and directs the active properties of all the cells and tissues, and the functions of all the organs and system of organs which make up the animal's corporeal frame. Its activities are: (1) mainly unfelt and occupied with the simplest vital processes of the organism. Amongst these there is much organic discrimination, and that automatic memory of the organism which, is, as it were, the basis of that felt memory which intervenes in the animal's mental activity; (2) They are those

* See Physical Basis of Mind, p. 383.

rious feelings and emotions which make up its mental powers. mmon sense is right, then, when it says "the cat sees, the cat hears, cat feels, the cat runs, plays, hunts," &c.; for it is the whole living ganism which does all these things, and not merely its brain, uscles, or any portion of that inseparable unity of which it consists. oreover, it is the invisible, immaterial entity which ever escapes r senses but which is visible to our reason, which is more truly and phatically THE CAT ITSELF, than is the matter of which it is com-sed. The energy, direction, and control belong to *it*, and without he cat is not. The dead body of the cat we may anatomise at ll, but the animal *itself* being dead has no existence, any more an a "corpse" is a "dead man."

The dead *body* of a man is a perfectly correct expression, but to eak of a dead man, a dead cat, or a dead bird, though, of course, ly permissible in popular speech, is really and philosophically to use expression as self-contradictory as it would be to say a "dead ing creature."

§ 16. The difficulty which some readers may possibly feel in nceiving the real existence of a distinct and substantial but (in elf) immaterial entity subsisting indivisibly as an innate principle every living organism, is due rather to the prejudice induced by popular tendency than to any reason which can be logically urged ainst it. "Sensationalism" is the vice of the day which tends to grade our art and literature as well as our science. We see it elcomed on the stage by crowds of sympathetic auditors, and this aving of our lower impulses is copiously fed by the less scrupulous our novelists.

Although it is the special dignity and prerogative of man, amongst imals, to apprehend the abstract and ideal, his tendency too often to repose in what is at once concrete and material. In the ld of speculation, we recognize this materialistic tendency in ose who refuse to recognize intellectual truths which cannot be rified by sense, and who forget that reason, not sense, is our timate criterion, and that it is the office of reason to criticise, and cept or reject the apparent testimony of the senses.

Reaction from this irrational tendency has given rise, and gives e, to a directly opposite conception. Thinkers who see clearly w often the essential nature of each object is misunderstood cause it is sought for only in matter, loudly proclaim that the ence of everything is an "idea," and thus, in seeking to escape m materialism, fall into the error of idealism.

Scientific truth, it is here contended, lies between these two posite errors. It recognizes, with the first school, that the essences living organism are not ideas but substantial realities. It also ognizes, with the second school, that such realities are not mere glomerations of matter, but are the expression of an immaterial nciple. It recognizes, in a word, that the dominant constituent every living organic being is neither material nor ideal, but an MATERIAL REALITY which the reason can apprehend and recog-e as *necessarily present*, but which the imagination can never

picture, for the simple reason that no reality of the kind can, from its very nature, be the object of sensible experience.

Such an immaterial reality is that indivisible, active principle or individual force, which was called Psyche by Aristotle, and which we may call "soul" or "form," in the sense of an individual living principle, absolutely one with the body it informs.

§ **17.** In order to make clearer what has been pointed out, it may be well to define more distinctly certain terms.

The *psyche* or *soul*, then, is that principle of individuation which makes the animal what it is, though it has no actual existence apart from the matter it vivifies. Yet it is the animal *par excellence*, the matter of which it is composed being but the subordinate part of that compound but indissoluble unity—the living animal.

The *action* of the psyche includes every vital action of the organism of whatsoever kind, each and every such action being a "*psychosis*" of one kind or another.

The specially animal activity of the organism—*animal psychosis*—is the sum of all those activities to which the nervous system ministers. Every such activity—every activity of living, neural matter—is a *neural psychosis*, and ends in a feeling, a secretion or a motion. Neural psychosis then may be either felt or unfelt, and amongst the felt actions of the kind, are all sensations, memories, imaginations, emotions and felt impulses tending to result in action, and those practical inferences before referred to. The sum of felt, neural psychoses in the cat, is the so-called "*cat-mind*" or *synesthesis*, and every felt neural psychosis is a *synesthetic* or so-called "*mental*" act.* The remaining, or vegetative activities of the organism—*vegetal psychosis*—is the sum of all those activities which result in nutrition and generation—the maintenance of the individual organism and the reproduction of new individuals. This form of psychosis exists by itself in plants, but in the animal organism is most intimately united with animal psychosis. It is so because, as we have seen in the cat, the nervous system ministers to nutrition and to reproduction as well as to feeling and to motion. The animal and vegetal psychoses are thus intimately united because the cat, being a true unity, can have but one principle of individuation—or psyche—which must therefore be the agent of all the vegetative as well as of all the animal psychoses which take place in it.

§ **18.** Such being the principle of individuation as made known to us in the adult animal, what are we to say of it in the earlier stages of the cat's existence?

* The terms "mind" and "mental act" are not, of course, properly applicable to the felt neural psychosis of the cat or of any unrational animal. They are here merely employed analogically in deference to popular usage.

The "mind" properly denotes the phenomena of our consciousness—the rational soul energizing both corporeally and consciously. Such action cannot take place without the aid of neural psychosis to furnish the images or phantasmata needful for all human mental action; but though so aided, the action itself is purely immaterial. The sum-total of the mental action of a rational animal may be called its *noesis*, which will be the analogue of the *synesthesis* or sum-total of the felt neural psychoses of an irrational animal.

This question cannot be duly considered without recognizing that though living creatures have principles of individuation of the most varied kinds, yet that they are susceptible of being classed in two groups—animals and plants.

As we descend to the lowest animals, the evidence as to sentience diminishes; while (from the resemblances of the lowest animals and plants, and from the similarity of the vegetative functions in all living creatures) we may analogically conclude that activities take place in plants which are parallel with, and analogous to the unfelt and non-neural psychoses of animals. As Asa Gray has said with respect to their movements: "Although these are excited by physical agents (just as analogous kinds of movements are in animals), and cannot be the result of anything like volition, yet nearly all of them are inexplicable on mechanical principles. Some of them at least are spontaneous motions of the plant or organism itself, due to some inherent power which is merely put in action by light, attraction, or other external influences."

Reference has already been made to insectivorous plants, such as *Dionæa*. In such plants we have susceptibilities strangely like those of animals. An impression is made, and appropriate resulting actions ensue. Moreover, these actions do not take place without the occurrence of electrical changes similar to those which occur in muscular contraction.

Nevertheless, nothing in the shape of vegetable nervous or muscular tissue has been detected, and as structure and function necessarily vary together, it is impossible to attribute sensations, sense-perceptions, instincts, or voluntary motions to plants, though the principle of individuation in each plant acts (in its degree) as do the unfelt psychoses of animals, and harmonises its various vital processes.

The conception then which commended itself to the clear (and certainly unbiassed) Greek intellect of more than 2000 years ago, that there are three orders of internal organic forces, or principles of individuation, namely, the rational, the animal, and the vegetal, appears to be justified by the light of the science of our own day.

We have no grounds for believing in the potential existence of sensation in plants, inasmuch as in the highest plants it is *not* made manifest, and no traces of sense organs have anywhere been found in them. Man apart—there are two orders of internal organic forces or principles of individuation—there is the animal, there is the vegetal, soul or psyche.

Now we have seen that the cat begins its existence as a minute spheroidal mass of protoplasm, which is capable of spontaneous division and which can imbibe nutriment and grow. It is comparable with a lowly organized plant. As function varies with structure we cannot deny a vegetal psyche to the creature at this stage of its existence, though we have no grounds for attributing to it as yet a really animal nature. But growth continues and produces a complexity of structure which demands a principle of individuation of a

higher order. Slowly the blastoderm is developed—the epibla[illegible]t becomes furrowed, and the developing matter grows here and ther[illegible]e into nervous and muscular tissue. We have then the organs of tru[illegible]e animal life, and we are therefore compelled to conclude that, in [illegible]a way which defies our powers of observation to detect, that veget[illegible]l principle which at first acted has disappeared to give place to [illegible]a truly animal psyche. But the embryo is, as yet, no cat, neither [illegible]s it like any other perfect animal. At first it is somewhat like [illegible]a worm, but afterwards its visceral clefts and arches and the cour[illegible]e of its blood current, show affinities (as we shall see in the thirteent[illegible]h chapter) with the class of Fishes. These conditions disappear, an[illegible]d are succeeded by a structure which, though of a higher nature, y[illegible]t for a time remains quite unlike that of a cat, and if the matter [illegible]f its body is not that of a cat, neither can its inner principle be th[illegible]t of such an animal. Change, however, follows on change, till th[illegible]e activity of the principle which is operating (of whatever kind,) h[illegible]s so prepared and modified the living mass, that the embryo comes [illegible]o assume the shape of a kitten. Simultaneously also, must that pri[illegible]- ciple of individuation which is proper to the cat, have informed th[illegible]e embryonic structure.

In the development of the individual therefore, we see a proce[illegible]s of singular and surprising change, during which a series of transito[illegible]y forms successively appear and disappear,* and which by suc[illegible]h

* These "forms" or "principles of individuation" must, of course, be considered to be of a different rank and order from those which inform perfect, or fully developed, animals. They are "transitory forms" specially destined for a merely temporary existence and for an end beyond themselves. They have, moreover, an essential relation to the parent form which produced them, and which they normally reproduce.

An embryo taken at any of the earlier stages of development, is certainly an animal of a distinct sort, but it is an animal of an imperfect nature, and not identical with any of the many kinds which exist permanently and independently.

Some readers may object that they cannot imagine the advent and departure of such immaterial entities; and that allowing that vegetal and animal psyches do really exist, it is more easy to imagine one such persisting through the whole series of developmental changes, than the succession above represented. Such objectors say what is quite true, but not to the purpose. It is not our "imagination," but our "reason," which has to decide such questions; for "imagination" is necessarily tied down to sense, and a "soul" of whatever kind is (like *all* that is immaterial) necessarily imperceptible by any of the senses. Facility of imagination is here therefore no te[illegible]st of truth, but rather the reverse.

If, however, function and structu[illegible]re ever go together as all physiologists w[illegible]ill admit, and if the existence of a soul [illegible]or principle of individuation be ever in a[illegible]y case admitted, how, it may be aske[illegible]d, could an animal psyche co-exist wit[illegible]th a merely vegetal organism, or a ration[illegible]al principle be present in a being whic[illegible]h has an organisation inferior to that of [illegible] worm? But even the spermatozoon a[illegible]n the unimpregnated ovum must be a[illegible]d mitted (on account of the intern[illegible]al activities they show in their dev-lo[illegible]p ment and growth) to possess some kin[illegible]d of life. Can, however, a human so[illegible]ul be believed to co-exist with either th[illegible]e one or the other? Yet some princip[illegible]le of individuation is present in each. W[illegible] have herein then an excellent example [illegible]of a succession of principles of differe[illegible]nt orders—a succession which cannot b[illegible]e denied by those who admit the existenc[illegible]e of such entities in any case. There [illegible]is nothing more repugnant to reason in b[illegible]e lieving that the conjunction of these el[illegible]e ments results in such successive materi[illegible]al transformations as prepare the advent [illegible]of the rational psyche by the previous pr[illegible]e sence of principles of inferior order[illegible]s than that their conjunction results i[illegible]n the disappearance of the two principle[illegible]s of the ovum and the spermatozoon an[illegible]

uccessive appearance and disappearance effect a true process of ontinued evolution—bringing about a precise, definite and pre-letermined end by the operation of internal powers, which are alled into active exercise in accordance with their own internal aws by the stimulus and co-operation of the various physical forces. Thus the psychology of the cat shows us that there is latent and otential in matter, special and peculiar substantial forms of force, uch as the psyche of the animal we are considering, and such as he various lower forms which transitorily manifest themselves as *ormæ transeuntes*, during its process of development. It also shows s that the very action of one such form may be so ordered as to esult in its own annihilation in order to give place to another, or the advent of which other its own activity has prepared the way, nd which other emerges from potential to actual existence the noment the matter has assumed the condition apt for the new orm's manifestation. The psychology of the cat is, as has been efore said more than once, the physiology of the creature in its ntirety. We shall hereafter have to consider another unity—that f the race—the evolution of which may, by a remote anology, be ermed "the physiology of the species." Such an expression is not, owever, exact, for a "species" is a creature of the intellect, and o such creature can have any real action; whereas the individual nimal, with its principle of individuation, is a concrete, really xisting, and really acting entity. Nevertheless we shall presently ee that the psychological considerations here put forward have heir bearing upon the question as to the origin and genesis of the irst cat and of the whole cat race.

he advent of the rational principle at nce. The essential notion is the same n either case, and the difference is but one f degree. To accept the latter belief, owever, completely contradicts the doctrine of the necessary correspondence of function with structure, and harmonizes rather with the fables of mythology than the teachings of science.

CHAPTER XII.

DIFFERENT KINDS OF CATS.

§ 1. In the first chapter of this work the principal varieties of the domestic cat were shortly described, together with its probable ancestors, the Egyptian cat and the common wild cat. But our knowledge of the cat would evidently be very incomplete if no acquaintance were made with the various animals most closely related to it, which now exist or have existed, and which may fairly be reckoned as "different kinds of cats."

In fact, cats of all kinds agree so closely in structure, and differ so decidedly, in that respect, from animals that are not cats, that they are universally admitted to form what is called a "very natural group"—that is to say, a group of animals easily characterized, and containing no members which differ strikingly from the other members of the group.

But though it is very easy to say whether an animal is a cat, it is often exceedingly difficult to determine what kind of cat it is. The lion, the tiger, the leopard, the puma, and the cheetah, and various other kinds of cats, are very well-marked forms. No one can mistake any of these animals one from another, but there are a great many smaller cats which are in a very different case. Many of them vary much in colour (and somewhat in shape and more in size) from individual to individual. Certain kinds have received from different naturalists more than one name, and it is often a task of much difficulty to find out which is the proper name which any given kind ought to bear.

To do this perfectly, it is necessary to examine the very individual skins which were originally described by the authors of the several names—which skins are the "types" of the various kinds or "species." When (as is very often the case) this is impossible, it is needful to critically examine the original descriptions, bearing in mind any collateral circumstances which may throw light upon the question as to which kind any particular author must have had in view when he wrote the original description. The investigation of this complex tangle of zoological literature is called the study of *Synonymy*, and it is often a study exceedingly difficult, on account of the too frequently very imperfect descriptions given by the

osers of new names. But there is yet another difficulty. Though lion, tiger, leopard, &c., cannot be mistaken one from another, all lions are by no means alike, nor are all tigers or all leopards . They all present individual variations, and these are some- s so marked that certain naturalists have thought it desirable istinguish one breed of lion by one name and another by another, so with leopards and other species. The questions then im- iately arise: (1) are these peculiar forms all "KINDS" such as nust take note of for our present purpose? and (2) what are circumstances which should lead us to consider any given form onstituting a distinct "kind" of animal?

ow, the various breeds of cats, such as we enumerated in the chapter, are called "varieties," while a lion and a tiger are not d two "varieties" but two "species." What is the difference, , between a SPECIES and a VARIETY?

2. The exact *philosophical* signification of the term "species" be considered in the last chapter; here, we may take it to have meanings—one MORPHOLOGICAL; the other, PHYSIOLOGICAL. ording to the first of these, it signifies a group of animals which alike in appearance. If two groups of animals differ markedly ppearance, and if no transitional forms are known which bridge , as it were, the difference thus existing between them, then two groups are reckoned as two distinct "species" according is first, or morphological, signification of that term, *i.e.*, they are *hological species*. The second use of the word "species" is to te a group of animals which can breed freely amongst them- s, but which, if united with animals of another appearance, will produce fertile cross-breeds with them; that is to say, they will roduce young which can go on indefinitely producing amongst selves a race of cross-breeds as freely as either set of parent als would have gone on reproducing forms like themselves. tures which are in this way restricted, are *physiological species*.

s to the various breeds of domestic cats, we know that they can rossed and will produce perfectly fertile mongrels, and therefore are not physiologically "species," however truly each breed, ng as it is uncrossed, will go on reproducing its own race—*i.e.*, go on "breeding true."

s to the wild cats of all kinds—lions, leopards, &c.—we know some of them will interbreed and produce young, but we have nowledge that such young will go on freely producing creatures themselves, while, from analogy with other animals, we should isposed to believe that they would not do so. Still we have as no observations to determine their specific distinctness *physio- ally*, and therefore we must as yet be content to judge of them hologically, by the absence that is of intermediate forms een the apparently distinct kinds. Whenever new forms are d so intermediate in character between two breeds previously ned as distinct species, that these new forms quite bridge over difference previously supposed to exist, then the supposed two

species must thenceforth be reckoned as one, and that one must bear the older of the two names previously in use.

There is a probability of physiological specific distinctness wherever there is an absence of transitional forms, for, if two kinds readily interbred and produced fertile offspring, transitional forms would, in most cases, soon abound.

For our present purpose, then, the "kinds" of cats which we have to consider are such kinds as we may reasonably, on morphological grounds, suppose to be "species" in the full sense of the term, and therefore, where the differences are confessedly slight and variable (as between different lions and different leopards), the creatures which present them will be reckoned as forming one species only.

When, however, the evidence is very scanty and incomplete, it is thought well that kinds should be distinguished provisionally by distinct names, on the authority of different naturalists, for fear any really important kind should get omitted from the list.

§ **3.** In zoology (as also in botany) each "species" has a name consisting of two words, which correspond with the Christian name and the surname of a man, except that their order is different—an animal's surname coming before the other name. The first word or term of an animal's name indicates to which "group" or "set" of species the animal named belongs; and as each "group" or "set" of species is called a "*genus*," this first word is called its "*generic* name. The second word indicates to which kind or "species" of the genus the named animal belongs, and so this second word is therefore called its "*specific*" name. Thus the zoological name of the wild cat consists of the two words, *Felis catus*. The first of these is the generic name, and indicates that the wild cat belongs to the group or "genus" FELIS. The second word is the specific name, and shows that the wild cat is that kind of the genus "*Felis*" which is distinguished as "CATUS."

§ **4.** Following the order which is traditional, the Lion, with its regal and national associations, may be taken first.

(1.) THE LION (*Felis leo*).*

This powerful and well-known cat is at once distinguished from all others, by the familiar fact that the male possesses a "mane," that is to say, that the hair of the head, neck, and shoulders is long. The hair also forms a tuft at the end of the tail, at the extremity of which, surrounded by the long hair, is a small, pointed, horny appendage. The rest of the body is mostly clothed with short hair. The adult lion is of a yellowish-brown colour, without spots or stripes, but the colour varies in intensity, and the long hair is often blackish. The young are marked with little transverse dark bands

* For a good figure of the skeleton, see De Blainville's Ostéographie, Felis, plates 5 and 9.

n each side of the body, and with a longitudinal black mark along he middle of the back. The mane begins to grow when the animal s about three years old, and is completed when it is about six ears old.

It is said to live for forty, and certainly lives for thirty, years, nd it attains a length of 9½ feet. The animal's internal organiza- ion is such as has been already described with respect to the cat, ave in certain details. Thus the pupil is round, never contracting nto a vertical slit. The anterior cornua of the hyoid bone do not ontinue up to the skull, but an elastic ligament, about six nches in length, connects, on each side, the lesser cornu of the s hyoides with the tympano-hyal. The intestine is four times the ength of the body.*

The convolutions of the brain are rather more contorted than in he cat, and the same is the case with all the largest species of cat- ke animals. The tapetum extends mostly below the optic nerve, nly a small portion being above it.† The nasal processes of the axillary bones end acutely, and reach backwards, on the dorsum of he skull, as far as, or a little beyond, the nasals.

In the skull of one old lion ‡ which I have examined, there is no race of upper true molars, or even of their alveoli.

The lion is not an arboreal animal, but roams over the plains of he countries it inhabits. It is found generally diffused in Africa, lso in Persia and Arabia, and in Cutch and Gujerat in Western ndia. It is occasionally met with as far east as near Allahabad. ormerly it existed all over central India and in South-eastern urope.§ We have no valid ground, however, for believing that a arge maned-cat, or lion, ever inhabited England or the adjacent art of Europe.

(2.) The Tiger (*Felis tigris*) ‖.

The Tiger is the largest and most powerful of all existing cats. It s of a bright rufous fawn colour on the dorsal surface of the trunk, ead, and limbs, with vertical and with transverse dark stripes on the ody, limbs and tail. These markings serve to distinguish it from very other cat. The hair of the cheeks is rather long and spreading. hat of the ventral surface is white. The animal may attain a length f ten feet six inches. Its maxillary bones end bluntly, and do not each as far backwards as do the nasals. The hyoid is connected to he skull by ligaments—as in the lion. The pupil is round, and ever linear. Tigers that prey on cattle will kill an ox about every

* Owen, Trans. of Zool. Soc., vol. i., p. 130 and 131.

† Owen, Anat. of Vertebrates, vol. iii., p. 252.

‡ No. 4504 A, in the museum of the Royal College of Surgeons.

§ Lions attacked the baggage camels of Xerxes when in Macedonia.

‖ See D. G. Elliot's Monograph of Felidæ, and De Blainville's Ostéographie, Felis, plate 7.

five days, and may destroy sixty or seventy head of cattle in a year. The tiger very seldom kills his prey by the "sledge-hammer stroke" of his fore-paw, so often talked about. His usual way is to seize it with the teeth by the nape of the neck, and at the same time use the paws to hold the victim and give a purchase for the wrench by which the tiger dislocates its neck.* It is naturally a cowardly animal, and retreats till provoked or wounded, and may even be made to drop its prey by cattle rushing at it in a body.

It will eat animals which it has not killed, and even its own species, for a tiger left wounded is related to have been dragged off by another tiger and partially devoured.† The tigress breeds once a year, and has from two to five pups. Hybrids between the lion and the tiger are sometimes produced in captivity.

The tiger is not an arboreal animal, but delights in thickets, especially near rivers. It is exclusively Asiatic, but has a very wide range, extending from Turkish Georgia, Mount Ararat, Persia, the Amoor land, and the island of Saghalien in the north, through China (including Corea) to the south of Hindostan, and the islands of the Indian Archipelago, down to Sumatra, Java, and the island of Bali; but it is not found in Borneo, nor in Ceylon.

(3.) The Leopard or Panther (*Felis pardus*).‡

This animal is very variable in size and in its markings, so that some naturalists consider that there are several species, which however seem ill-defined and variable. It is generally of a yellowish rufous fawn colour, with many dark spots grouped in rosettes, while the tail is ringed and the ventral surface is whitish. The head and body are about three feet ten inches long, and the tail is about two inches shorter.

There is a well marked variety which, though black, shows the usual markings when viewed in certain lights.

Its pupil is round. The hyoid is connected with the skull by ligaments, and not by a continuous chain of bones.

The leopard is an arboreal animal. Though so much smaller than the tiger, old women and children are not unfrequently killed by it.

This species has a very wide range, being found in Africa from Algeria to Cape Colony, and in Asia from Palestine and Japan to Ceylon and Java.

A leopard has been described by Professor Alphonse Milne-Edwards, under the name of *F. Fonteirii*,§ and is said to be distinguishable by the shorter muzzle, longer and more copious fur, and by the markings on the flanks being more like rings than rosettes.

* Forsyth's Highlands of Central Asia, p. 257.

† Jerdon's Mammals of India, p. 94.

‡ See Elliot's Mon., and De Blainville's Ostéog., plate 8.

§ Recherches sur les Mammifères, p. 208, plates 29, 30, and 31.

The tail also is shorter than the body. Two individuals have been obtained: one from China, the other from Persia.

Fig. 165.—Skull of Leopard (*F. pardalis*).

(4.) The Ounce (*Felis uncia*).

This is a very interesting species, exhibiting to us, as it does, a

Fig. 166.—The Ounce (*F. uncia*).*

large feline animal adapted to live in a cold climate, as the mammoth was exceptionally so adapted amongst elephants.

* See Elliot's Monograph, from which the above figure has been, by kind permission, copied.

It is clothed in a dense long fur, which even forms a short mane. It is from four to four and a half feet long without the tail, which measures a yard. The fur is of a pale yellowish grey, with small irregular dark spots on the head, cheeks, back of neck and limbs, and with dark rings on the back and sides. It is whitish beneath, with some large dark spots about the middle of the abdomen; the rest of the belly is unspotted. The long bushy tail is surrounded by

Fig. 167.—Skull of Ounce (*Felis uncia*).

incomplete black bands. The length of the head and body is four feet four inches, that of the tail three feet.

The skull is very high, but concave in front of the orbit when viewed in profile. The nasals are remarkably short and broad.

The pupil is round.

The Ounce is found in the highlands of Central Asia and the Himalayas, where it ranges from 9000 to 18,000 feet, rarely descending very much below the snows. It has, however, been found as far west as Smyrna.* It is said to frequent rocky ground, and to feed on wild and domestic sheep, goats and dogs, but has never been known to attack man.

An animal has been described † as a new species of ounce, under the name *F. tulliana*. It seems to be more slender than *F. uncia*, with longer legs, and with a longer and narrower head. Its hair is also less long, thick and soft, while the annular spots are more numerous and smaller, and the round spots on the upper part of the back are smaller than those of the flanks. The tail is less thick and still less completely annulated.

* Jerdon's Mammals of India, p. 101.

† See Valenciens, Comptes Rendus, 1856, t. xlii., p. 1035, and Tchichatcheff's Asie Min., 1856, vol. ii., p. 613, plate 1.

(5.) The Puma or American Lion (*Felis concolor*).*

5. The Puma is a large cat, somewhat like a rather slender
ess, as it is unstriped and unspotted when adult, and devoid of a
ıe. It is of a reddish brown or reddish grey colour generally,
tish beneath. The young are marked with blackish brown spots,
ch disappear at about the end of the first year.
ts head is proportionately rather small compared with those of
large cats already noticed. Its length from snout to tail-root is
erally about forty inches, and it has a tail of some twenty-six
ıes.
he skull is remarkable for its depth anteriorly. The os hyoides
onnected with the skull by a continuous chain of bones, as in
cat.
he pupil is round.
he puma eats deer, small quadrupeds, and the Rhea, or American
ich, and sometimes destroys human life. It is said to kill by
nging on the shoulders of its prey and then drawing back the
d with one paw till the neck is broken.
t is a remarkably silent animal, never roaring like the lion and
r.
t inhabits a very wide range, being spread over America from
Straits of Magellan to Canada, and ascending the Andes to
0 feet altitude.

(6.) The Jaguar (*Felis onca*).†

his is also a New World species, and the most powerful of the
ıerican cats. Its colour and markings are like those of the
ard, save that its spots are larger and more definitely arranged
roups, forming series of dark rings, each ring generally enclosing
or more spots within it. There is, however, a considerable
unt of individual variation in the extent and arrangement of
se markings, and the most southern forms are said to be
erally yellow and sometimes almost white.
n size the jaguar somewhat exceeds the leopard.
A prominent bony tubercle exists on the middle of the inner or
al edge of the orbit.‡
he pupil is round.
A variety has been described § and figured by Dr. Gray as *Leopardus
nandesii*.

* See De Blainville, *l. c.*, plate 6, Baird's Mammals of North America. also Godman and Salvin's Biologia trali-Americana, Mammalia, by E. Alston, p. 62.

† See Elliot's Monograph, also Cuvier's mens Fossiles, plate 34, pp. 3 and 4, and De Blainville, *l. c.*, plate 3; also Biologia, p. 58.

‡ This tubercle exists also in some other cats, but is not so largely or constantly developed in any other species as it is in the jaguar.

§ Pro. Zool. Soc., 1857, p. 278, plate 58.

The jaguar is a very fierce animal, and often destroys men and women. Its favourite haunts are the wooded banks of rivers, and its habitual food is the giant rodent—the capybara. This great cat ranges from the Red River, Louisiana, and the Rio Bravo, Texas, down to the most northern parts of Patagonia, *i.e.*, to 40° south latitude.

(7.) The Clouded Tiger (*Felis macrocelis*).*

§ 6. This very handsome and interesting animal—the last of the series of very large cats—has a coat, the ground colour of which is

Fig. 168.—The Clouded Tiger (*Felis macrocelis*).

a brownish grey, marked with stripes and spots of black, which form large and irregularly disposed patches. The under parts are, as usual, whitish. The cheeks and sides of the head are marked with two parallel bands, one extending backwards from the eye to beneath the ear, the other more or less parallel, and passing backwards from above the angle of the mouth.

The animal is about forty-two inches long from snout to tail-end,

* See Pro. Zool. Soc., 1853, p. 192. It is described also by Jerdon in his *Mammals of British India*.

while the tail itself (which is ringed with black) is some thirty-two inches.

The limbs are short compared with the body and very long tail, and the head is somewhat elongated compared with that of any of the cats yet noticed.

The skull is very long and low. The orbit is widely open behind.

The animal differs from all the cats yet noticed, in that it has not the tooth described as the first upper premolar, while that answering to the common cat's second upper premolar is not very large.

Fig. 169.—Skull of the Clouded Tiger (*Felis macrocelis*).

The upper canines, however, are exceedingly long, longer relatively than in any other living cat. The upper sectorial tooth has a large inner cusp.

The pupil is neither round nor linear when contracted, but has an oblong aperture.

This animal affords a good example of the great individual differences of disposition which may exist in the same species of cat. One specimen in our Zoological Gardens was a most tame and gentle beast, while another was quite exceptionally ill-tempered and savage.

The clouded tiger dwells in trees. It preys upon such animals as sheep, goats, pigs or dogs.

Its range, though extensive, is more restricted than that of any species yet noticed, as it inhabits only a portion of south-eastern Asia, from the eastern Himalayas, through Burmah, Siam and the Malay peninsula, to Sumatra, Borneo and Java. It also inhabits Formosa. One from the last-named island has been described by Mr. Swinhoe as a distinct species.* It is, however, only a somewhat brighter coloured and shorter tailed variety.

* As the short-tailed clouded tiger (*Felis brachyurus*). (*Leopardus brachyurus*, Swinhoe, Proceedings of the Zoological Society, 1862, p. 352, plate 43).

(8.) The Thibet Tiger Cat (*Felis scripta*).*

A much smaller cat, but with markings somewhat like those of the clouded tiger, has been discovered in the mountains of Thibet by the Abbé David, and made known and named by Professor Alphonse Milne-Edwards, who has described it as follows:—

General colour pale grey inclining to yellow, with reddish brown spots and more or less complete black margins. In the scapular region these spots form longitudinal, undulating bands—looking a little like Chinese writing. The largest of these dark lines begins near the inner angle of the eye, and goes thence above the ear to the scapular region of the back and then descending obliquely, widens out. A similar line, placed higher up, extends from the forehead to the shoulder. There are large irregularly shaped spots on the sides of the body. At the hinder part of the back they form bands and bars, not complete rings, on the tail. Part of cheek, neck and chest white, with transverse black markings. Belly yellowish, with longitudinal black marks. There are black spots and bands outside the legs.

The iris is of a yellowish chestnut colour.

Length of the head and body twenty-one and a half inches, of tail ten and a half inches.

The first upper premolar is small, and appears soon to fall out, as on one side of the skull figured the tooth is wanting.

It inhabits Monpin in Thibet.

(9.) Fontaneir's Spotted Cat (*Felis tristis*).†

This cat may be distinguished from the other species of the same countries as it inhabits, by its large size, whitish grey colour and large spots. It is described as follows:—

Fur soft and long; general colour a whitish grey. Three or four blackish brown lines, beginning in the centre of the head, between the ears, run along the whole length of the back; rest of the body, flanks and legs covered with large spots of dark brown. Underparts lighter than the upper, legs profusely marked and spotted with brown. Two bars of rufous brown pass across the upper part of the breast. Tail very long and bushy, rufous brown above, yellowish brown beneath. The upper part presenting a series of obscure dark brown bars.

Length of head and body, thirty-three and a half inches; length of tail, sixteen inches.

This animal inhabits the interior of China. The skin of the typical specimen was bought at Pekin.

* A. Milne-Edwards, Nouvelles Archives du Muséum, 1870, t. vii., Bulletin, p. 92, and Recherches, p. 351, plates 57 and 58, Fig. 1.

† Alphonse Milne Edwards, Recherches des Mammif., p. 223, plate 31 D, and Elliot's Monograph.

(10.) The Bay Cat (*Felis aurata*).*

This is a large one-coloured cat, and a very distinct species. It from twenty-eight to thirty-one inches long from snout to tail, ile the tail measures sixteen or nineteen inches. It is a bay-red ove, paler beneath and on the sides, with a few indistinct spots on e flanks. The throat is whitish, while the tip of the tail and the rs, internally, are blackish. The ventral surface is reddish white, otted brown. There are two black streaks on each cheek, with a le black-edged line over the eyes.

The pupil is said by Hodgson to be round.

According to Mr. Jerdon it inhabits Nepal and Sikim. Dr. Gray ds as habitats, Sumatra and Borneo, and one (received by the ological Society from Amsterdam) is said to be from Sumatra.

(11.) The Fishing Cat (*Felis viverrina*).†

This well-marked and very distinct species was originally described Bennett in 1833, and the type of the species is preserved in the itish Museum.

Its hair is short and rather coarse. Though usually of a general rk grey colour (darkest on the back), specimens may occasionally found of a reddish grey ground tint. It is always covered with rk brown spots, smallest and least conspicuous on the shoulders. he head and back have three or four dark brown lines going ngthwise, which, however, upon the lower back and rump become oken up into spots like those on the flanks and other parts. Two ackish brown lines pass across the cheek, one from behind and ie from beneath the eye, and a line of the same hue crosses the roat just below the chin. Throat and breast white, the latter ossed by three or four blackish brown lines passing from shoulder shoulder. Belly same colour as flanks, spotted with blackish own in continuous lines crosswise. Inside of legs greyish white, ith from two to three dark brown bars crossing the upper part ar the body. Tail rather short, slender, same colour as the back, rred above with chestnut brown, the bars going diagonally, and eeting in the centre, forming a V-shaped mark; tip chestnut own. Underneath greyish white. Length of head and body, irty to thirty-two inches; length of tail, nine to twelve inches. he skull is elongated above. The orbits are completely encircled bone. The first upper is present but is very small.

* *Felis aurata*, Jerdon's Mammals of itish India, p. 107; *F. moormensis*, dgson; *F. Temminckii*, Vigors; *opardus auratus*, Gray; Cat. Brit. as., p. 12.

† Bennett, Pro. Zool. Soc., 1833, 68. It is described in Mr. Elliot's nograph, from which the above figure is taken. It is also described by Jerdon in his Mammals of British India, p. 103. It is the animal named *Viverriceps Benettii*, by Dr. Gray, in his Catalogue of the Carnivora, p. 17, Fig. 5, and in Pro. Zool. Soc., 1867, p. 286, Fig. 5, which figure has been here reproduced.

Mr. Jerdon says that the pupil is circular. He also tells us that *F. viverrina* "is found throughout Bengal to the foot of the south-eastern Himalayas, extending into Burmah, China, and Malayana,

Fig. 170.—The Fishing Cat (*F. viverrina*)

and that it is common in Travancore and Ceylon, extending up the Malabar coast as far as Mangalore."

Fig 171.—Skull of *F. viverrina*.

Mr. Buchanan says that besides fish it eats *Ampullariæ* and *Unios*, and that it has a very disagreeable smell. It is exceedingly fierce, and has been known to carry off children.

(12.) The Leopard Cat (*Felis bengalensis*).*

There is a very distinctly spotted cat from northern India which is thus named by Mr. Elliot in his Monograph. Either this kind is subject to great variations in colour and markings, and somewhat also in size, or else there are several distinct species, which cannot yet be accurately defined for want of a sufficient number of specimens.

Mr. Jerdon gives as the size of his species thus named: "Length of head and body twenty-four to twenty-six inches; tail eleven or twelve

Fig. 172—Skull of *F. bengalensis*.

inches and more." He says it is variable, both as to the ground colour and the size and boldness of its markings, though all adhere to one general pattern.

The ground hue varies from fulvous-grey to bright tawny yellow, occasionally pale yellowish grey or yellowish, rarely greenish-ashy, or brownish-grey; lower parts pure white; four longitudinal spots on the forehead, and in a line with these four lines run from the vertex to the shoulders, the outer one broader, the centre ones narrower, and these two last are continued almost uninterruptedly to the tail; the others pass into larger, bold, irregular, unequal, longitudinal spots on the shoulders, back and sides, generally arranged in five or six distinct rows, decreasing and becoming round on the belly; two narrow lines run from the eye along the

* See Jerdon's Mammals of British India, p. 105. This animal is the *Felis pardochroa* of Dr. Gray (Pro. Zool. Soc., 1867, pp. 273 and 400; and Catalogue of Carnivora, p. 28). It is also his *F. tenasserimensis* (Pro. Zool. Soc., 1867, p. 400; and Catalogue, p. 28) and his *F. Elliotí*. The last named is only represented by skulls in the British Museum, but these are quite similar to the skulls of *F. pardochroa*. It is also the *F. nepalensis* of Dr. Gray. Mr. Elliot, in his Monograph, identifies his *F. bengalensis* not only with Dr. Gray's above-mentioned species, but also with his *F. Wagati*, as to which latter identification I hesitate to follow him.

upper lip to a dark transverse throat-band; and two similar transverse bands run across the breast, with a row of spots between; tail spotted above, indistinctly ringed towards the tip; the inside of the arm has two broad bands, and the soles of all the feet are dark brown. There is generally a small white superciliary line. I have noticed in several specimens in the British Museum, that the black spots unite or tend to unite over the shoulders, so as to make a conspicuous oval black ring, not unlike the "*Vesica piscis*." This is not, however, always to be detected.

There is in the National Collection a skin* which came from the Indian Museum, and which differs considerably from all the specimens of *F. bengalensis* that I have seen, in its redder colour, more woolly hair, and thicker tail, as also in the less distinctness of its markings. It is not however in very good condition. It is said to have been brought from Nepal by Mr. B. H. Hodgson. The length of the head and body is twenty-two and a half inches; that of the tail is sixteen inches.

A first upper premolar tooth is present, but it is very small. The orbit is nearly encircled by bone. The post-orbital process of the frontal of the specimen figured has been unfortunately broken. *F. bengalensis* inhabits Nepal, Thibet, Darjeeling, Assam, Burmah, the Malay Peninsula, Sumatra, and Java.

(13.) The Wagati (*Felis Wagati*).

The cat in the British Museum which is thus named, is very like *F. bengalensis;* but it is a smaller animal, and its black markings are more sharply defined and decidedly in the form of short black stripes. The animal also has not the small spots on the flanks which exist in *F. bengalensis*, and the stripes on the shoulders are nearly parallel and do not tend to form an oval ring. It has been described by Dr. Gray as follows: "Fur fulvous; nose, chin, throat, and underside of body, and streak on forehead and cheek, pale yellow. Spots of body few, large, irregularly shaped; of withers, large, elongate, broad; of loins, elongate, narrow, more or less confluent; tail with round spots."

Length of head and body, twenty-one and a half inches.

Length of tail, eleven inches.

Habitat, India.

(14.) The Marbled Tiger-Cat (*Felis marmorata*).†

This cat attains a size of from nineteen to twenty-three inches from snout to tail, the tail itself being about fifteen inches. It is a very distinct species.

* Skin No. 79. 11. 25. 563. It is labelled *F. Duvancelli.*

† *Catolynx marmoratus*, Gray, Pro. Zool. Soc., 1867, p. 267; *Felis Charltoni*, Gray, Pro. Zool. Soc., 1856, p. 396; and *Catolynx Charltoni*, Pro. Zool. Soc., 1867, p. 268, and Cat. of Carnivora, p. 16.

The ground colour of its coat is dingy fulvous, occasionally ellowish grey, with numerous elongate, wavy, black spots, somehat clouded or marbled. On the sides of the body are large regular patches of a darker shade and with dark margins, specially on the hinder edge of each patch. The head and nape ave some narrow blackish lines coalescing into a dorsal interrupted and; a dark line extends backwards from between the eye and the outh; the thighs and part of the sides with black round spots; the

Fig. 173.—The Marbled Tiger-Cat (*F. marmorata*).

ail black spotted, with a black tip. The belly is yellowish white. The colour becomes more fulvous with age.

There are several skulls of this species in the collection of the British Museum. These all agree in having the orbit nearly or ompletely enclosed by a bony ring—the postorbital process of the rontal meeting the postorbital process of the malar in the older pecimens. The skull is very broad at the zygomata. The first pper premolar is very small, and the first lower premolar is not ery prominent. The premaxillæ ascend and join the frontals, hus separating the nasals from the maxillæ on the surface of the kull. The pterygoid fossa is rather well developed.

The pupil is said to be linear.

This species ranges from Nepal through Burmah and Malacca Java and Borneo.

(15.) The Serval (*Felis Serval*).*

§ 7. This large and well-known African cat has long legs and a short tail. It is of a more or less tawny colour, with black spots, and black rings on the tail. The underparts are whitish. Towards the middle of the back the spots tend to run together into two longitudinal bands. There is no dark streak upon the cheek, but there are two strongly marked transverse black bars across the inside of the upper part of each fore-leg.

The length of the head and body may be as much as forty inches, that of the tail may be sixteen inches.

The pupil contracts into an oblong opening.

There is not only a first upper premolar, but the second upper premolar is largely developed.

This animal inhabits Africa from Algiers to the Cape.

(16.) The Golden-haired Cat (*Felis rutila*).†

This species is founded upon a skin described by Mr. Waterhouse in 1842, and which (the type of the species) is preserved in the British Museum, but is unfortunately mutilated.

Its colour is red-brown, with indistinct small darker spots on the sides; back, dark brown medianly; belly white, with large brown spots; tail red-brown, with a dark central line extending along its dorsal surface, while at each side it is pale, with obscure indications of darker bands.

Length of head and body about twenty-eight inches; of tail, fourteen inches.

The skull has the orbits incomplete behind. There is a very small first upper premolar.

Habitat, Sierra Leone and Gambia.

There are two cats only known to me by description, as to the distinctness of which I am too much in doubt to venture to enumerate them as distinct kinds. They are *F. celidogaster* and *F. senegalensis*.

Felis celidogaster was named by Temminck,‡ who thus describes it:—

"Fur short, smooth, shiny, grey, with a reddish tint, with chocolate or light brown spots; spots on dorsal line oblong, the

* This is described and figured in Mr. Elliot's Monograph.

† Waterhouse, Pro. Zool. Soc., 1842, p. 130; Gray, Pro. Zool. Soc., 1867, pp. 272 and 395; Cat. of Carnivora, p. 23. *F. chrysothrix* of Elliot's Monograph. He identifies it with both the *F. aurata* and the *F. celidogaster* of Temminck, and with the *F. neglecta* of Gray.

‡ Esquisses Zoologiques, p. 87.

ers round; cheeks and lips whitish, with small brown spots; roat and chest with six or seven half-circular brown bands; lower rts and inner sides of the limbs pure white, with large round ocolate-brown spots; two bands of this colour on the inner side of e fore, and four on the hind feet; tail bay-brown, with paler own rings, end black brown; outer surface of the ears black; ws white."

Length of body and head, twenty-six inches; that of tail, fourteen ches.

Mr. Elliot identifies this with the *F. neglecta* of Gray and the *rutila* of Waterhouse (P. Z. S. 1871, p. 759), and describes it in s Monograph under the name *F. chrysothrix*.

The other doubtful species is *Felis senegalensis* of Lesson.* The r of this animal is of a uniform reddish grey, paler beneath, with ack spots inclining on the back to run into longitudinal stripes; ots on limbs; tail ringed; two black stripes from eye to ear; uzzle, chin, and throat white.

The individual described was about the size of the domestic cat, nd was regarded as probably immature. It seems probably to ave been a young Serval.

Habitat, Senegal.

As to this species or variety Professor Alphonse Milne-Edwards as been so kind as to inform the author that no specimen of it xists in the Paris Museum. The original description was made rom a living animal at the hospital of Rochefort-sur-Mer. A oung Serval in the Paris Museum closely resembles the description f *F. senegalensis*, but has a tuft of hairs on each ear.

(17.) The Grey African Cat (*Felis neglecta*).†

This is rather smaller than the last species, and is well distinguished by its grey colour. The type is in the British Museum, nd was originally described by Dr. Gray as follows:—

"Grey; head and body marked with numerous small darker ots, spots of the lower part of the sides rather larger; belly white, ith large blackish spots; tail quite half the length of the body, ith a dark line along the upper surface, sides paler, with obscure dications of darker bands."

No dark streak on the cheek.

Habitat, Gambia.

* Lesson, Guérin's Mag. de Zool., 39, t. x., Mammifères.

† Gray, Ann. and Mag. Nat. Hist., 38, vol. i., p. 27; Pro. Zool. Soc., 67, pp. 272 and 294; and Brit. Mus. Cat., p. 24. Mr. Elliot, in his Monograph, identifies this with the species last described; but to me it appears very distinct from the latter.

(18.) The Servaline Cat (*Felis servalina*).*

This animal is apparently of about the same size as *F. neglecta*, but is distinguished from it by its colour, which is yellow, fulvous above, and white beneath. The middle of the back is darker, with very numerous small black spots, spots on sides rather larger, on the belly much larger; tail short, fulvous, with five or six imperfect black rings, and a pale tip. No cheek streaks.

The type is said to be in the British Museum.

Habitat, Sierra Leone.

(19.) The Ocelot (*F. pardalis*).†

§ 8. This beautiful cat, always handsomely marked, is either one of several closely allied species, or else, as is more probable, is subject to much variation as to coloration and the intensity of its markings. Besides the typical form, Dr. Gray has distinguished four marked varieties (or species) which he has named *F. grisea*, *F. melanura*, *F. picta* and *F. pardoides*, and certainly these forms are not only very different when adult, but, as Dr. Gray says, their characters are to a certain extent permanent, the young, in some instances at least, being like their parents, so that they are at least varieties which "breed true."

The ground colour of the ocelot may be tawny yellow or reddish grey. It is always marked with black spots, which are aggregated in chain-like streaks and blotches, generally forming elongated spots, each with a black border, enclosing an area which is rather darker than is the general ground colour. The head and limbs bear small black spots, and there are two black stripes over each cheek and one or two transverse dark bands within each fore-leg. The tail tends to be ringed, and the ventral parts of the trunk and limbs are whitish.

Length from snout to tail-root ranges from twenty-six to thirty-three inches; that of the tail varies from eleven to fifteen inches.

The pupil contracts into a vertical slit. The orbit is not enclosed by bone.

The creature is a ready climber, and is said to be exceedingly bloodthirsty.

The variety called *F. grisea* ‡ is of a grey colour, even somewhat whitish at the sides; that named *F. picta*,§ differs from the typical *F. pardalis* in its less intense coloration, the less degree of approximation of its stripes and the less amount of difference which

* Ogilby, Pro. Zool. Soc., 1839, p. 4; Gray, Pro. Zool. Soc., 1867, p. 395; and Catalogue of Carnivora of Brit. Mus., p. 24; Sclater, Pro. Zool. Soc., 1874, p. 495, plate 63. Mr. Elliot identifies this in his Monograph with the Serval, but in this I cannot at all agree with him.

† Described and figured in Elliot's Monograph. He considers the here enumerated varieties to be merely varieties. See also Godman and Salvin's Biologia, Mammalia, p. 60.

‡ Gray, Ann. and Mag. of Nat. Hist., vol. x., p. 260, 1842; and Pro. Zool. Soc., 1867, p. 403.

§ Gray, *l. c.*

ts between the general ground colour and the parts enclosed by black borders of the spots and markings. The variety termed *ardoides* * is very like the variety *F. grisea*, but the spots affect the form of rings upon the flanks, while the stripes on the neck less distinct as well as shorter, the ground colour of the neck g redder. There are also more or less spots in the middle of back. It differs from the typical *F. pardalis* by its grey ur.

his greyness in *F. pardoides* and *F. grisea* is not the effect of since it already exists in the kittens.

'. *pardoides* measures about twenty-five inches from snout to root, and the tail is thirteen inches long.

'ery different from all the foregoing, as well as from the typical *ardalis*, is the variety which has been named *F. melanura*.† Its urs are most intense. The ground colour being bright fulvous, the black markings exceedingly numerous and deep, while the te parts stand out in strong contrast to the rest.

he ocelot ranges from Arkansas to Paraguay, and according to Elliot, even to Patagonia.

ertain other smaller and beautifully-spotted American cats are difficult to distinguish one from another; but it seems to me e are probably three distinct kinds, which are represented in National collection, and are named *F. tigrina*, *F. guigna*, and *ardinoides*.

(20.) The Margay (*Felis tigrina*).‡

he animal thus named must be another very variable species, e what I believe to be but different varieties have been de- ed as three distinct species, under the names of *F. tigrina*, *nitis* (the Chati), and *F. macroura*.

he *F. tigrina* of the British Museum.§ has rather harsh fur, of a grizzled colour, varied with black spots and rings. The tail is ked with small black spots, often confluent, but not forming inuous rings. There are three transverse black stripes on the k. The head and body together measure a little over twenty- inches, and the tail is about eleven inches long.

he specimens named *F. mitis* and *F. macroura* || have soft, bright, ous fur, with black spots of variable size, but which are not ed in chains. The black-bordered patches sometimes have a centre.

Gray, Pro. Zool. Soc., 1867, p. 403. Pro. Zool. Soc., 1867, pp. 270 and

See Biologia, Mammals, p. 61. Messrs. Alston and Elliot have d in considering that the three ties are merely varieties; having to this conclusion after together examining the fine series of specimens in the museum at Paris as well as in the British Museum. I adopt their decision, though I do not feel sure that the *F. tigrina* and *F. mitis* of the British Museum, may not be distinct species.

§ Gray, Pro. Zool. Soc., 1867, p. 404.

|| Gray, *l. c.*, p. 271.

The length of the head and body is nearly twenty-seven inches, that of the tail from fourteen to nineteen inches.

The animal ranges from Mexico to Paraguay, in warm lowlands and well-wooded regions.

An American variety of cat has been described by Hensel* as *Felis guttula*. The account given does not make it clear that it is a distinct species. The author's description is as follows:—

"Skull long and narrow, corresponding with that of *F. macroura*, the facial part is smaller compared with the brain-case. Especially striking is the height of the skull between the orbits.

"Ground colour grey yellow; two dark stripes on the head, and a dark stripe from each eye to the forehead; four stripes, tolerably broad, run side by side together on the neck to the shoulder. The sides of the neck are furnished with some dark marks, and some dark brown or black spots are scattered over the whole fur. In the middle of the back (where the ground colour is darkest) there are narrow more or less short stripes, which sometimes run one into the other, forming longer stripes. On the flanks the spots are larger and have a lighter centre, which, anteriorly, so approaches the ground colour as to change the spots into rings. The limbs are much spotted externally. The under parts are lighter (or whitish) and less spotted. There is a white spot outside the external ear. Tail reaching forwards to the arm, with ten or eleven rings and a black tip. Size that of the domestic cat."

Habitat, South Brazil—Rio Grande do Sul.

(21.) Geoffroy's Cat (*Felis guigna*).†

The *F. guigna* of the British Museum was described by Dr. Gray‡ by the name *Pardalina Warwickii*, under the impression that it came from India, but was recognized by Dr. Sclater§ as being the South American Cat described by D'Orbigny.‖ The latter animal is indeed so like the *F. guigna* of our National collection that I cannot help identifying them as specifically the same, although D'Orbigny's animal is not so much spotted.

It may be described as follows:—

"Fur short, dusky whitish brown; chin, streak on cheek, and throat white; chest and underside paler, black-spotted; crown and nape with four, cheek with two, and between the withers one black streak; the four feet and body covered with very numerous, equidistant, nearly equal-sized small black spots; throat, chest, upper

* Abhand. Akad. Berlin, 1872, p. 73.

† Molina, Saggio sulla storia naturale del Chili, i. Ausgb., p. 295. See Elliot's Monograph, under the name *Felis Geoffroyi*. See also a paper by Dr. Philippi, in Wiegmann's Archiv, 1873, p. 8, plate 3, where two views of an immature skull are given.

‡ Gray, Pro. Zool. Soc., 1867, pp. 267 and 405, plate 25; and Catalogue of Carnivora, p. 14.

§ Pro. Zool. Soc., 1870, p. 706; and 1872, p. 203.

‖ D'Orbigny's Voyage dans l'Amérique Méridionale, Mammifères, p. 21, plate 14

rt of the inside and outside of fore and hind-legs black-banded; il spotted at the lower half, ringed at the end, with a black tip; rs black, with a large white spot."

Fig. 174.—Skull of Geoffroy's Cat (*F. guigna*).

The skull is very short and broad, and convex above at the muzzle. Orbits not completely enclosed; first upper premolar very small. It inhabits Paraguay and Chili.

(22.) The Ocelot-like Cat (*Felis pardinoides*).*

This animal was also first described by Dr. Gray under the misken supposition that it came from India.† The type of the ecies came from the Zoological Society's collection, with the retation of an Indian origin. A second specimen, however, cerinly received from Bogota, placed its real geographical region eyond doubt. It is very like *F. guigna*, but the spots are much rger and in the form of dark blotches, each with a black border. he two skins differ somewhat, the type of the species being reyer than the skin subsequently received. The skulls also are ifferent, but not more so than difference of age may suffice to count for, the typical specimen being immature.

The length of the head and body is about eighteen inches, that f the tail being ten inches.

As has been said, it comes from Bogota.

* This animal is identified by Mr. lliot with that last described, though allows them to be good "varieties." It appears to me that they should provisionally at least be held as distinct.

† Pro. Zool. Soc., 1867, p. 400.

(23.) The Yaguarondi (*Felis Yaguarondi*).*

The Yaguarondi is one of the few unspotted cats, like the lion and puma. It has a very long tail and a long body, in proportion to the limbs, and its head is long and low.

It is of a blackish or brownish grey, with individual variations, both greyish and reddish specimens being found in the same locality. Each hair being blackish grey at the root, then black and greyish again towards the point.

The female is said to be of a lighter, brighter colour than the male.

The animal is thirty inches from snout to tail, while the tail is twenty-five inches long.

The pupil is said to be round.

The skull is elongated and somewhat flattened above, but what is exceedingly characteristic of the species is the remarkable way in which the nose is, as it were, pinched in laterally.

It inhabits Brazil, Guiana and Paraguay, and North-eastern Mexico.

(24.) The Eyra (*Felis Eyra*).†

This is the most remarkable of all the cats, from the extreme

Fig. 175.—The Eyra (*Felis Eyra*).

length of its body in comparison to that of its limbs—a condition which gives it somewhat the appearance of a large weasel. It is also one of the few unspotted cats.

The fur is soft, of a uniform reddish-yellow or chestnut colour,

* See Biologia, Mammals, p. 63. † Biologia, Mammals, p. 64.

a whitish spot on each side of the upper lip. It is about size of the domestic cat, save that its legs are much shorter that animal's.
he pupil is round.*
he skull is much elongated and greatly flattened above.
he nose is a little pinched in laterally.
he first upper premolar is present.
he specimen in the Zoological Gardens was very gentle, but her one was quite untameable.
inhabits Brazil, Guiana and Paraguay, and though rare north- ls of Panama, extends upwards to the Rio del Norte between ico and Texas.

(25.) The Colocollo (*Felis colocollo*).†

his animal is about the size of the common cat or somewhat er. It is of a whitish-grey colour, with elongated black marks he back and sides, and with a black mark extending from the to the jaw. The tail is said to be semi-annulated and the r parts of the limbs to be of a dark grey hue.
he skull has the orbits not enclosed by bone.
here is no first upper premolar. The upper true molar is le when the skull is seen in profile. The infra-orbital fora- is large. The skull is much elongated and depressed. The zle produced, and the upper surface of the snout markedly ave when the skull is looked at in profile. When the skull en from above, the prominence of the upper jaw causes part he anterior palatine foramina to be distinctly visible. The ls narrow very gradually backwards, and do not extend so far wards as do the nasal processes of the maxillæ.
he animal inhabits Guiana and Chili, and doubtless intermediate tries alos.

(26.) The Rusty-spotted Cat (*Felis rubiginosa*).‡

9. This pretty little cat is said by Mr. Jerdon to frequent hwood and grass growing in the dry beds of tanks, as well ie jungle.
s colour is greenish-grey, with a faint rufous tinge; beneath inside of limbs white; a white superciliary streak extending on

This has been kindly ascertained for y Mr. A. D. Bartlett, of the Zoolo- Society.
Hamilton Smith in Griffith's Animal dom, vol. ii., p. 479 (with a figure); uvier's Mammifères, iii.; *F. Strigi-* Wagner's Supplement to Schreber's th., vol. ii., p. 546. See also a by Dr. R. A. Philippi, in Wieg- mann's Archiv, 1873, vol. i., p. 8, plate 3, Figs. 1 and 2.

‡ See Mr. Elliot's Monograph, from which the above figure has been taken. It is the *F. rubiginosa* of Jerdon's Mammals of British India, p. 108; and the *Viverriceps rubiginosa* of Gray, Pro. Zool. Soc., 1867, p. 269; and Catalogue of Carnivora, p. 18.

the side of the nose; two dark face streaks; top of head and nape with four narrow dark brown stripes, becoming interrupted posteriorly, and passing into a series of rusty-coloured marks, which on the back, are in the form of streaks, but are roundish on the sides of the body. Tail short, more rufous than the body, and

Fig. 176.—The Rusty-spotted Cat (*F rubiginosa*).

uniform in colour, or very indistinctly spotted, the tip not dark; the lower surface and inside of the limbs with large dark brown spots; feet rufous-grey above, black on the soles; ears small; whiskers long, white; fur short and very soft.

It is a very small animal, the length of the head and body being only sixteen or eighteen inches, and that of the tail about ten inches. It is a well marked species.

The skull is elongated, though its facial part is short. The orbit is nearly encircled by bone, and the mastoid process is rather prominent. The nasal bones are long and narrow, extending backwards beyond the adjacent parts of the maxillæ. The first upper premolar is wanting.

It is said to inhabit both Madras and Ceylon.

A cat has been described by M. Alphonse Milne-Edwards under the name of *F. chinensis*, and a similarly named specimen, which agrees with the description referred to, is in the National collection. The latter is the type of a species named *F. chinensis* by Dr. Gray.

(27.) The Chinese Cat (*Felis chinensis*).*

This animal presents the following characters:—

General colour pale yellowish grey, interrupted by a multitude

* Pro. Zool. Soc., 1870, p. 629; and Catalogue of Carnivora, p. 27. Also A. Milne-Edwards, Recherches des Mammiferes, p. 216, plate 31. fig. 2.

of more or less dark brown spots. Two narrow, elongated white marks commence beside the nose and extend on to the forehead, and another, in each zygomatic region, extends back on the neck beyond the angle of the jaw, with a deep red-brown border above and below. Muzzle, lower parts of cheeks and chin white, except part of the upper lip, which is yellow and striped. Fine, blackish stripes on the head, all but the middle one extending to the beginning of the back. Chest whitish, with reddish-brown spots, which tend to form transverse bands like a series of incomplete collars. The spots form elongated markings along the back and sides; sometimes the spots of the sides form leopard-like rosettes, but sometimes they do not do so.

Length of head and body about twenty-five inches.

Length of tail, twelve inches.

The orbits are nearly enclosed by the post-frontal processes. The nasals extend backwards about as far as do the maxillæ. The first premolar falls early.

The animal is found near Canton and in Formosa.

(28.) The Small Cat (*Felis minuta*).*

This animal is very like that last described, but it is smaller, and the tail is much shorter. The spots also are less rounded and more in the form of short stripes. The orbits are nearly enclosed by bone, as in *F. chinensis*, but the nasals extend backwards decidedly beyond the hinder ends of the adjacent parts of the maxillæ.

Length of the head and body, twenty-three inches.

Length of the tail, six and a half inches.

This animal inhabits the Indian Archipelago, including Borneo and at least the island of Zebu in the Philippine group of islands. The *F. Herschelii* of Gray† appears to be but a light-coloured variety of *F. minuta*.

(29.) Jerdon's Cat (*Felis Jerdoni*).‡

This animal is very like *F. chinensis* and *F. minuta*, but it is smaller, and the spots which mark it are darker and more distinct, and they do not so distinctly form stripes on the shoulders.

The fur is grey, with a few small, distinct black spots. The spots on the sides of the body and of the limbs are roundish; those of central part of back are linear and rarely confluent. Tail and feet

* Gray, Cat. of Carnivora, p. 26.

† Pro. Zool. Soc., 1867, p. 401; and Catalogue, p. 28.

‡ The specimen in the British Museum which is thus named, was so named orally by Mr. Blyth, but was not described till Dr. Gray described it in the Pro. Zool. Soc., 1867, p. 401; and Catalogue, p. 28. Mr. Elliot identifies this with his *F. rubiginosa*, but the two appear to me to be distinct.

dark grey brown, scarcely spotted; chin and under parts, white with black spots.

Length of head and body, seventeen and a half inches.

Length of tail, five and a half inches.

(30.) The Javan Cat (*Felis javanensis*).*

This form is added doubtfully as a distinct species. It is represented in the British Museum by a specimen of small size and of a greyish-brown colour with round spots, of a reddish-brown tint, on the sides, and with blackish longitudinal streaks along the back. There are two stripes on the cheek. Beneath, it is whitish, with largish, brown spots.

Length of the head and body, twenty-two inches.

Length of the tail, seven and a half inches.

(31.) The Bushy-tailed Red-spotted Cat (*Felis euptilura*).†

This species was first described by Mr. Elliot from a very imperfect skin,‡ which is the type of the species, and is preserved in the British Museum. There is also there preserved a specimen from Shanghae, which closely resembles the skin described by Mr. Elliot and is similarly named.

The following is Mr. Elliot's description:—

"Ground-colour of the body light brownish-yellow, strongly mixed with grey, covered with reddish-brown spots rather oblong in shape, darkest and most conspicuous on the hind quarters; head grey, with a white line under the eyes and on the side next to the nose; two dark brown stripes on the centre, commencing at the tip of the nose, and one on each side, beginning at the eye, pass over the top of the head, and down the back of the neck to the shoulders; a dark-red stripe runs from the corner of the eye, across the cheek to the base of the ear; and another, rather lighter in colour, starting below the eye, passes across the cheek and curves back under the throat. The centre of the back is much darker than the sides, with spots of dark brown. Under lip white, as is also the throat and under parts. Across the upper part of the breast are four broken bands of foxy red; belly covered with large brown spots, becoming rufous between the hind legs. Inner side of hind legs buff, with cross bands of foxy-red, and covered with small reddish spots to the toes. Tail thick, rather short, bushy, darker than the body, with several incomplete broken rings of blackish brown. Inside of ear buff, behind black."

Size about that of the common cat.

The orbits are nearly enclosed by bone. The nasal bones extend back decidedly beyond the nasal processes of the maxillæ. The nasal region is much pinched laterally. There is a small upper front premolar.

* Gray, Catalogue of Carnivora, p. 26.

† Elliot, Pro. Zool. Soc., 1871, p. 760, plate 76. It is also described and figured in his Monograph.

‡ No. 52. 3. 19. 1.

(32.) The Small-eared Cat (*Felis microtis*).*

This cat is very like *F. chinensis*, but differs from it by the small size of its ears. The infra-orbital foramen is, moreover, divided.

The hair is long, soft, and very abundant. The general colour is that of *F. chinensis*, but the spots are redder and more confused; the markings of the zygomatic region are less distinct, as are those on the head and neck. The ears have each two white spots behind, separated by a vertical blackish-brown band, while in *F. chinensis* the ears are black and have but a single white spot. The tail is not distinctly spotted. It inhabits the neighbourhood of Pekin, and is also found in Mongolia.

(33.) The Large-eared Cat (*Felis megalotis*).†

This animal appears to be only known by Müller's description. He tells us:—"This new species is of the size of *Felis minuta*; it has, however, much longer and more projecting ears and a much larger tail, which is not round but more or less flattened. The general colour is yellowish, the back reddish-yellow, and the under parts more of an isabella colour The hairs of the head, neck, shoulders, hind legs and tail are annulated with black rings, which results in giving a marbled appearance to the body There are some transverse black stripes on the hind legs, and some reddish-yellow and black stripes on the fore legs. The claws are light yellow. A dark stripe proceeds from beneath the eyes to the ears, where it breaks up into narrower stripes. The hairs of the tail are longest at each side, so as to form a lateral fringe, which gives the tail its flattened appearance. The tail is partly ringed in an indistinct manner. The ears are bluish-white within. The iris is orange-yellow.

(34.) The Flat-headed Cat (*Felis planiceps*).‡

This very peculiar and exceptional cat is one-coloured, with a long body and short legs and tail.

It may be thus described:—

Fur thick, soft, and long. Top of head dark reddish-brown. Two yellow lines extend upwards (one on each side) from between the eyes to near the ears; body dark brown, darkest on the back,

* Alphonse Milne-Edwards. Recherches p. 221, plates 31*a* and 31*b*, Fig. 1. See also the right-hand figure in Mr. Elliot's plate of *F. cuptilura*. Mr. Elliot identifies this species with his *F. cuptilura*. The figures, however, appear to me very different, and I think it best to keep it distinct, at least provisionally.

† Müller, Verhand. over de Natuurlijke Geschiedenis Zool., Leyden, 1839–1844, Part I.; Over de Zoogdiernen van den Indischen Archipel., by Salomon Müller, p. 54.

‡ See Mr. Elliot's Monograph, from which the above figure was, by permission, copied. It is the *Viverriceps planiceps* of Gray, Pro. Zool. Soc., 1867, p. 269; and Catalogue of Carnivora, p. 17. It is the *F. planiceps* of Vigors and Horsfield, who first described and figured it in the Zoological Journal, vol. iii., p. 449, plate 2.

every hair tipped with white, a silvery-grey appearance being thereby given to the cat. Face beneath the eye light reddish, with two narrow dark lines across the cheeks to beneath the ears. Throat, breast, and belly white, the latter spotted and marked with rufous. Inside of legs rufous-brown, growing light towards the

Fig. 177.—The Flat-headed Cat (*F. planiceps*).

feet. Tail rather short and thickly furred and of a reddish-brown

Fig. 178.—Skull of Flat-headed Cat (*Felis planiceps*)

colour above, beneath yellowish-brown. It is about the size of a domestic cat.

Length of head and body from twenty-one to twenty-four inches.
Of tail, from six to eight inches.

The skull is elongated and the orbits are completely enclosed by bone, but its most remarkable character is the large size of the first premolars both above and below. The first upper premolar is two-rooted and largely developed, its crown being sometimes actually longer from above downwards than is the sectorial tooth. The first lower premolar is also as vertically extended as is the second. This structure would accord with a fish-catching habit, like that which is attributed to *Felis viverrina*.

Dr. Gray gives Malacca, Sumatra, and Borneo as the habitat of this species.

(35.) The Bornean Bay Cat (*Felis Badia*).*

This unspotted and therefore exceptional small species of cat was first made known by Dr. Gray from a very imperfect skin (the type of the species) which is now in the British Museum. It is thus described:—

"Fur of a bright chestnut colour, rather paler beneath, the limbs and the tail being rather paler and redder. The tail is elongate, tapering at the end, with a white central streak occupying the hinder half of the lower side, gradually becoming wider and of a purer white towards the tip, which has a small black spot at its upper end. The ears are rounded, covered with short blackish-brown fur at the outer side, pale brown within, and with a very narrow pale margin. The sides of the upper lip, a small spot on the front angle, and the edge of the upper eyelid pale brown. The chin, edge of the under jaw, and gullet whitish."

The orbits are nearly encircled by bone, and there is a good-sized pterygoid fossa. Unlike *F. planiceps*, this cat has its first upper premolar of but small size and with a single root.

Habitat: Sarawak, Borneo.

(36.) The Egyptian Cat (*Felis caligata*).†

§ **10.** This species varies from pale fulvous, to grey or pale yellowish, with darkish transverse markings on the legs and towards the end of the tail, and two transverse streaks on the cheeks.

As has been said in the first chapter, this species is probably the main source of the domestic cat.

According to Dr. Gray, "Many specimens of *Felis caligata* from Africa, like *Felis domestica*, *F. indica*, and *F. torquata*, and many other species, have the hinder part of the feet black; but this is not a permanent character; for some of the paler specimens of *F. caligata* have the hind feet paler than the back of the animal,

* Gray, Pro. Zool. Soc., 1874, p. 322, plate 49.

† Gray, Brit. Mus. Cat., p. 29; *Felis maniculata*, Rüppell, Zool. Atlas, i., t. 19; *Felis Chaus*, Rüppell, Zool. Atlas, i., t. 140.

and some of these have the heels more or less brown or blackish on the outer edges."

The tail is long.

Pale varieties of this cat seem to have been mistakenly described as identical with the jungle cat (*Felis Chaus*) of India, and also with the Indian, *Felis torquata*.

(37.) THE WILD CAT (*Felis catus*) has been already sufficiently described in the first chapter.

(38.) THE INDIAN WILD CAT (*Felis torquata*).*

This cat has much resemblance to the European wild cat, but it is more fulvous and less striped, and is more slender in its build.

Length of the body and head from sixteen to eighteen inches.

Length of tail, ten to eleven inches.

Habitat: India.

(39.) THE COMMON JUNGLE CAT (*Felis Chaus*).†

The common jungle-cat is of a yellowish-grey colour, more or less dark and unspotted, approaching to rufous on the sides of the neck and abdomen, where it unites with the lower parts; a dark stripe extends from the eyes to the muzzle. The ears are slightly tufted, rufous black externally, white internally.

The limbs have two or three dark stripes internally, and they are occasionally faintly marked externally also.

The tail is short, reaching to the heel, and more or less annulated with black—most so in the young.

Length of head and body, twenty-six inches; of tail, nine to ten inches.

Pupil, oblong erect.

Skull with the orbits open behind, and with the upper premolar distinctly developed.

This cat ranges all over India, from the Himalayas to Cape Comorin and Ceylon, and from the sea level to 8000 feet elevation.

(40.) THE ORNATE JUNGLE CAT (*Felis ornata*).‡

This cat "is at once well known from all the other Indian species by the dimensions of the tail and the small size and equal distribution of the spots. In this respect it resembles the Hunting

* F. Cuvier, Mammifères; *Felis inconspicua*; Gray, Pro. Zool. Soc., 1867, p. 273; and Catalogue of Carnivora, p. 31.

† Jerdon, Mammals of India, p. 111; *F.* (*Lynchnus*) *erythrotis*, Hodgson; *F. Jacquemontii*, Is. Geoffroy St Hilaire; *Chaus Jacquemontii*, Gray, Pro. Zool. Soc., 1867, p. 275, and Brit. Mus. Cat., p. 34; *Chaus Catalonyx*, Gray, Brit. Mus. Cat., p. 36. See also Elliot's Monograph.

‡ Gray, Illustrations of Indian Zoology and Pro. Zool. Soc., 1867, p. 401; *Chaus ornatus*, Gray, Pro. Zool. Soc., 1867, p. 275; and Brit. Mus. Cat., p. 35; *F. torquata*, Jerdon's Mammals of Brit. India, p. 110. See also Elliot's Monograph.

Leopard. The tail is somewhat like that of *F. Chaus*. The ears are slightly pencilled at the tips. The fur is short and of a pale whitish-brown. The spots form transverse bands on the legs. The belly has black spots like those of the sides."

Length of head and body, nineteen inches; that of tail, eight inches.

The skull has the orbits open behind, and the nasal bones are very long and slender. There is a distinct first upper premolar.

It is said to breed rather freely with Indian domestic cats. *

Habitat: desert regions of North-western India.

(41.) The Steppe Cat (*Felis caudatus*).†

The following are the characters of this animal:—

Fur close, soft, pale yellowish, blackish brown at the base, with very numerous small irregular spots. The spots are smallest and roundest on the dorsal line, oblong on the sides, and forming interrupted lines on the shoulders and thighs, which are most distinct on the outside of the fore-legs, and especially forming four broad cross streaks on the front edge of the thighs; tail cylindrical, reaching to the ground, spotted at the upper part of the base, and with eight or nine narrow interrupted rings on the upper part of the remaining portion, with a black tip. Nose brown, with short hair. Forehead and cheeks like the back, but with smaller spots, and without any distinct dark streaks from the back edge of the eye. The ears ovate, acute, pale brown externally, with a terminal pencil of blackish hairs, and whitish on the edge within. Chin, hinder parts of the upper lip, under parts of the head, throat, chest, belly, inside of legs, and hind feet whitish brown, the chin being whitest and the inside of the hind legs and feet darkest. There is a large blackish spot on the upper part of the inside of the fore legs, and two small cross streaks on the front edge of the inside of the thighs. The hinder part of the hind feet to the heel blackish. Length of body and head, twenty-three inches and a half; of tail, twelve inches and a half; height of shoulder, twelve inches.

The orbits are incompletely encircled by bone. There is a small anterior upper premolar. The anterior lower premolar is large.

Habitat: Bokara.

(42.) Shaw's Cat (*Felis Shawiana*).‡

This cat appears to be distinguished from *F. caudatus* by its much shorter tail; from *F. Chaus* by being spotted throughout, and from *F. ornata* by its short tail, more rufous coloration, and distinct black

* See Blyth, Pro. Zool. Soc., 1863, p. 184. The same is said to be the case with *F. Chaus* and *F. rubiginosa*.

† Gray, Pro. Zool. Soc., 1874, p. 31, plates 6 and 7, under the name of *Chaus caudatus*.

‡ Blandford, Journal Asiatic Society of Bengal, vol. xlv., part 2, p. 49.

spots on the abdomen. It is very different from *F. euptilura*, which has red spots on the sides and rufous bars across the breast.

Length, from snout to root of tail, twenty-five inches; of tail, seven and eight inches.

The skull is very long.

General colour pale greyish fulvous above, the back rather darker than the sides, underparts white; the body marked throughout with rather small black spots, which are largest on the abdomen, smaller and closer together on the shoulders and thighs, tending to form cross lines on the latter, and indistinct on the middle of the back; anterior portion of the face and muzzle whitish, cheek stripes of rusty-red and black hairs mixed. Ears rather more rufous outside, especially towards the tip, which is blackish-brown, and pointed, the hairs at the end scarcely lengthened, interior of ears white. There are some faint rufous spots at the sides of the neck. Breast very faintly rufous, with one narrow brownish band across. Inner sides of limbs mostly white, a black band inside the forearm, and a very black spot behind the tarsus. Apparently there are two black bands inside the thigh. Tail dusky above near the base, with five or six black bars above on the posterior half, none below, the dark bars close together towards the tip. Fur soft, moderately long; the hairs purplish-grey towards the base. Size, larger than the common cat, about equal to that of *F. Chaus*.

Habitat: Eastern Turkestan, Yárkand, and Káshgar.

(43.) The Manul (*Felis Manul*).*

This handsome animal is the wild cat of Thibet, Mongolia, and Siberia. It is smaller than the common cat, with very long, soft and abundant hair. It is of a pale whitish colour, varied by a slight black mark on the upper part of the legs and chest. The hairs are yellowish-grey at the base, then yellowish, with their points white. There are a few transverse dark bands on the loins, which are black, narrow, and rather far apart. A white streak, bordered by black above and below, passes obliquely downwards and backwards from behind the eye, and there is another black mark behind the ear.

Length from snout to root of tail, twenty-one inches.

Length of tail, ten inches.

The skull is remarkable for its breadth and the prominence of the interorbital region as compared with the nasal region. The nasal bones are very narrow for their hinder two-thirds, and then broaden out rather suddenly, forwards.

Habitat: Thibet to Siberia.

* Alph. Milne-Edwards, Recher. des Mam., p. 225, plate 31c; Grey, Pro. Zool. Soc., 1867, p. 874; and Catal. of Carnivora, p. 33.

Fig 179. THE MANUL (*F. Manul*).

(44.) THE STRAW OR PAMPAS CAT (*Felis pajeros*).*

This animal is about the size of our wild cat, but is more robust in build, with a smaller head and a shorter tail. The hair is long, and the colour of the body is yellowish-grey, marked with transverse bands of yellow or brown, which run obliquely from the back to the flanks. Two patches descend from the eyes over the cheeks, and meet beneath the throat. The animal is whitish beneath. The legs and tail are marked with dark bands.

Length from snout to tail root, twenty-five inches; length of tail, twelve inches.

The skull has the snout remarkably short, and therefore is very convex above anteriorly when seen in profile. The nasal region is much pinched in laterally, and the nasals are very narrow in their hinder half. The zygomata are greatly arched outwards. The first upper premolar is wanting. The cusp of the first lower premolar is much prolonged.

This animal appears to be a New-World form which represents as it were *F. Manul* of the Old World.

It inhabits the Pampas and Patagonia down to the Straits of Magellan.

* Gray, Pro. Zool. Soc., 1867, p. 269; and Catalogue of Carnivora, p. 18. For the skull, see a paper by Dr. R. A. Philippi, in Wiegmann's Archiv, 1878 p. 8, plate 3, figs. 3 and 4.

(45.) The Northern Lynx (*Felis lyncus*).*

§ 11. The lynxes are animals which present a markedly different aspect from that of other cats. Their legs are long and their tail is, with one exception (that of the caracal), very short. Their ears also are tufted at the tip. The pupil is linear when contracted. The orbits are incompletely surrounded by bone. They have no tooth representing the common cat's first upper premolar, while that answering to its second upper premolar is largely developed. The intestines are also very short.†

The lynxes thus form a little group apart, being structurally more separable from the bulk of the cats than are the lion, tiger, jaguar, puma, and leopard, which are separable from the mass of feline animals as the emphatically "large cats." Still the above given characters are variable in the cat group. In some cats, other than lynxes, the tail is short, and some have the ears more or less pencilled. Some, as we have seen, have long legs, and in many the first upper premolar is wanting. The lynxes therefore cannot be separated off as a nominally distinct group or "genus."

The lynxes are very variable in their colour and markings, and the northern lynx also varies greatly in the abundance of its hair, according to the season—the animal having a very different aspect in winter from that which it presents in summer. The northern lynxes are generally reckoned as forming two species, one belonging to the old world, *F. borealis*, and at least one species belonging to the new, *F. canadensis*. The American forms are also often described as alone constituting three species—namely, *F. canadensis*, *F. rufa*, and *F. maculata*. After a careful examination of the rich series of skins at the British Museum, I am, however, not only quite unable to regard the American varieties as anything more than varieties, but I am inclined to the opinion that there can be no real specific distinctness between the northern lynxes of the two hemispheres—their skulls as well as their skins being so much alike.‡

A. The variety generally distinguished as *F. borealis* is of a reddish-grey colour, sometimes more or less spotted, sometimes very distinctly so—especially when young. Its winter dress is more grey in colour and is much longer and thicker than its summer coat.

* De Blainville, Ostéog. Felis, plate 3.

† According to Professor Owen (Trans. Zool. Soc., vol. i., p. 131), they are only twice the length of the body, being relatively the shortest intestine known to exist in the *Felidæ*. The hyoid is connected with the skull by a continuous chain of bones, as in the common cat. The ciliary folds of the eye are very long, and the retina, which is very thin, does not reach the meridian of the eyeball, Owen, Anat. of Vertebrates, iii., p. 252.

‡ On this question Professor Alphonse Milne-Edwards has been so obliging as to send the following statement of his opinion:—"The study of the different kinds of lynx is a very difficult study. Whether there are several species in the northern hemisphere, or only races, is a question which I cannot answer. There are certainly distinct forms, but before ranking them as species it would be necessary to determine what variations are due to climate, season, age, sex, &c."

he fur of the cheeks is generally long, so much so as to form a endent thick fringe on each side, but the extent of this develop-ent varies greatly. The pads of the feet are more or less over-rown with hair.

It inhabits Northern Scandinavia, Russia, Northern Asia, and me of the mountainous districts of Central Europe. One was lled at Wurtemberg as late as 1846, and in 1822 one was killed France at St. Julien Chapteril, in the department of the Haute oire.

This animal is said to attain the length of fifty inches, but I have en none longer than about forty inches from snout to the root of e tail.

B. The variety known as *F. canadensis*, is, in colour, very like *. borealis*, but all the specimens I have seen are smaller, being about irty inches from snout to tail root, with a tail five inches long.

C. The variety named *F. rufa** is, as its name implies, of a ddish colour; its fur is shorter and less abundant than that of the ariety named *F. canadensis*.

Fig. 180.—The Northern Lynx, variety *F. maculata*.

D. The variety called *F. maculata* is a very handsome one, its r being ornamented with many spots; but skins exist which esent every transitional condition between the long-haired spotted rm known as *F. maculata* and the other American forms. This ariety extends across the North American continent from the Rio rande to Southern California, going at least as far south as

* Biologia Centrali Americana, Mammals, p. 64.

Guanajuato,* and probably extending to near the city of Mexico. It is therefore an interesting kind, as being the most southern form of Lynx as yet known to exist. The *F. maculata* figured measures thirty-five inches from snout to tail root, and the tail is six inches long.

(46.) The Pardine Lynx (*F. pardina*).

This is the South European lynx. The colour is rufous above, white beneath, with numerous rounded black spots over the body, the limbs, and the tail.

It presents no noticeable difference as to size from *F. lyncus*.†

At first I was disposed to regard this form as a mere variety of the northern lynx (the species thus becoming spotted in southern latitudes in the old world, just as it becomes spotted in the warmer regions of the new world), but an examination of the skulls inclines me to regard *F. pardina* as a really distinct species. When the skull is seen in profile it differs from the skulls of the varieties *F. borealis*, *F. canadensis*, *F. rufa*, and *F. maculata*, in that it appears much more raised and convex between the orbits, while the skulls of the four just named varieties are relatively flat. The nasals of *F. pardina* extend backwards beyond the nasal processes of the maxillæ.

This species is found in Turkey, Greece, Sicily, Sardinia, and Spain. In Andalusia it is very often called *Gato serval*, an interesting indication of the African origin of part of the population of that Province.

(47.) The Thibet Lynx (*F. isabellina*). ‡

This form is only ranked as a species provisionally and with much doubt. There is in the British Museum the mounted skin of a large lynx, which is uniformly of a very pale isabella colour.

Length of head and body, forty-one inches.

Length of tail, seven inches.

Though so markedly different in colour it may be but a pale variety of *F. lyncus*. §

(48.) The Caracal (*Felis Caracal*). ‖

The caracal is a well-known kind. It is of a slender build, with long limbs and with a tail longer than in the other lynxes, reaching down to the animal's heels. The ears are three inches long.

* Biologia, *l. c.*, p. 65.

† There is a specimen in the British Museum which measures forty-one inches from snout to tail-root, with a tail seven inches long, and which is covered with black spots. It is labelled *Lyncus lupulinus*, and has been described by Dr. Gray (Pro. Zool. Soc., 1867, p. 276) as a new species. It was brought from the museum of the Zoological Society, and is represented as having come from Norway. But this representation was probably erroneous.

‡ This is the *F. isabellina* of Blythe. Gray, Pro. Zool. Soc., 1867, p. 276.

§ Dr. Scully has very kindly shown me the skins obtained by him in Central Asia, one of which at least is intermediate in coloration between *F. lyncus* and *F. isabellina*.

‖ Jerdon's Mammals of British India, p. 113. See also Elliot's Monograph and De Blainville's Ostéographie, plate 10.

It is of a uniform vinous, or bright fulvous brown colour above, and paler, sometimes almost white, beneath. It is quite or almost entirely spotted, but some obscure spots are visible, in some specimens, on the nks, belly, and inner surface of the limbs. The tail has a black tip. The pads of the feet are bald. The skull is rather convex tween the orbits, as in *F. pardina*.

Length of the head and body, twenty-six to thirty inches.

Length of the tail, nine or ten inches.

This animal is found in North-western India and in Central India the east coast: also in Thibet, Persia, Arabia, and throughout rica.

(49.) The Common Cheetah or Hunting Leopard (*Cynælurus jubata*).*

§ 12. This cat differs much more from all the other cats than any her two cats differ one from another, and it therefore may be dis-guished as constituting a nominally distinct group or "genus."

It has a short rounded head, with long, slender limbs and a long il. Its ears are rounded, and not at all pencilled.

It is a large animal, being four and a half feet long in head and dy, and with a tail two and a half (or two and three-quarters) t long.

Its colour is bright rufous fawn, powdered with black spots. These not like those of the leopard—arranged in rosettes, nor, as in jaguar, in rings; neither do they run together into stripes or ngated patches, but are distinct, plain, round marks. The tail, wever, is more or less ringed with black. The hair of the neck ns something of a mane, and that of the belly is long and light-oured.

A black stripe runs downwards from the inner angle of the eye to margin of the upper lip near the angle of the mouth.

Such are its colour and markings when adult. The young are ered with long soft hair of a dark-brown colour, very obscurely tted. The head, the back of the neck, the back, and the upper face of the tail, are pale brown. They have altogether a singularly erent appearance from the adult.

The cheetah has the claws always more or less exposed, not being npletely retractile as in the other cats, though it is furnished with same kinds of ligaments that they have.

The skull of the cheetah is also very different in shape from the ll of every other cat—being very high in proportion to its gth. The nasals are short, but not so short as in the ounce. ere is more than one infra-orbital foramen on each side. The per true molar is visible when the skull is seen in profile. The

Jerdon's Mammals of India, p. 114; *parda*, Gray, Pro. Zool. Soc., 1867, 96; and Cat. Brit. Mus., p. 39: De Blainville, Ostéog., *Felis*, plate 4 (skeleton).

first upper premolar may be present or absent. The second premolar is very large, projecting downwards as much as does the sectorial.

Fig. 181.—The Cheetah (*Cynælurus jubata*).

The upper sectorial differs from the corresponding tooth in all living cats, in that the inner cusp of that th is so rudimentary as to be almost wanting.

Fig. 182.—The Young Cheetah.

The os hyoides is connected with the skull by a continuous chain of bones—as in the common cat.

The metacarpals and metatarsals are relatively long.

The brain is considerably convoluted.*

The corpus albicans is fairly divided into two corpora mammillaria, as in various other large cats.

The pupil is round when contracted.†

The animal, as is well known, is employed for the chase, being taken to the hunting field in a cart, with a hood over its head. Mr. Jerdon has observed it, when let loose after the game, crouch

Fig. 183.—SKULL OF THE CHEETAH (*C. jubata*).

along the ground, and seek out every inequality of surface to enable it to get unseen within proper distance of the antelope it was pursuing. Nevertheless it can run with a velocity as great as that of a well-mounted huntsman.

The cheetah is found at least in Western, Central, and part of Southern India, also in Syria, Mesopotamia, Persia, and Africa, to near the Cape—certainly in both Senegal and Kordofan.

(50.) THE WOOLLY CHEETAH (*Cynælurus lanea*).‡

This species has been recently described by Dr. Sclater, and appears to me to be distinct, though Mr. Elliot regards it as a mere variety of the common cheetah.

* See Owen, Trans. Zool. Soc., vol. i., plate 20.

† Of this I have been made aware through the kindness of Mr. A. D. Bartlett.

‡ Pro. Zool. Soc., 1877, p. 532, plate 55.

It differs from the latter in that it is thicker in the body, and has shorter and stouter limbs, and a much thicker tail. Its fur is also more woolly and dense, particularly on the ears, mane, and tail. The whole of the body is of a pale isabelline colour, rather paler on the belly and lower parts, but covered all over, including the belly, with roundish, dark, fulvous blotches. There are no traces of the black spots which are so conspicuous in the cheetah, nor of the characteristic black line between the mouth and the eye.*

The animal described came from Beaufort West, in Cape Colony.

§ **13.** With the last-named animal closes the list of LIVING CATS which it is thought may certainly, probably or very possibly, be considered as distinct "species." But while doubtless some new species may yet be discovered, yet it is, on the other hand, very probable that various forms here enumerated as very possibly or probably distinct may turn out to be mere varieties. The domestic cat is said to breed, in India, with *F. Chaus* and *F. rubiginosa*, and with other species in Ceylon and Africa, and the produce of some of these unions may themselves be fertile, and if so, the parents must be classed as belonging to one and the same species.

Casting a retrospective glance over the characters of the species described, we see that they differ but in few points. The uniformity of their structure, and even of their colour, is very remarkable. Some reddish or yellowish shade more or less modified by grey or brown, may be said to be their ground tint, marked generally with spots, often with stripes more or less black, with the under parts of the body whitish. Very generally there are two transverse stripes on the cheeks, and bars on the inside of the upper arms, with dark rings round the tail. There are no wild kinds of a pure white, nor is there any black or black-and-white species, while it is only a few kinds that are of a uniform tint and unspotted. The various kinds differ in size, in details of colour, in the length of the hair of certain parts, in the length of limbs compared with that of the body, and in the length of tail. They also differ as to the presence or absence of a tuft of hair on the ear-tips, the form of the skull, the enclosure or non-enclosure of the orbits by bone, the presence or absence of a first upper premolar, the relative size of the first and second premolars, the size of the internal cusp of the upper sectorial tooth, the more or less perfect retraction of the claws, and the shape of the contracted pupil.

Besides these characters, certain details of brain-structure, the condition of the anterior cornu of the os hyoides, the proximity of the stomach to the diaphragm, and the relative length of the intestine, are known to be different in different kinds, and no doubt various other such divergences exist which have not as yet been noted. Indeed, these latter anatomical details have been examined in too few forms to enable them to be yet made use of for purposes of classification.

* This line is, however, indicated on one side of the muzzle of a specimen now living in the Zoological Society's Gardens.

The living cats being thus uniform in structure, one alone stands ut as markedly distinct. This is the Cheetah—with its imperfectly-etractile claws and rudimentary cusp of the inner upper sectorial ooth, its high skull, long limbs and tail, and long metacarpals and netatarsals. In it also we saw that the first premolar may be resent or absent, but that the second premolar is greatly developed ertically. Altogether this animal may, as has been said, rank as a roup or genus by itself, the genus *Cynælurus*, of which genus the bove characters will form the definition. The Lynxes may also, as ve have seen, be grouped by themselves, but they can hardly be eckoned as forming a distinct genus, although their special geo-raphical range—being almost entirely creatures of the north emperate zone—is a noteworthy character.

All the other cats, however, must, without question, be included in a single genus, *Felis*.

It has been proposed to separate off, as a distinct genus, the cats with a vertical pupil and an orbit closed behind by bone, and to divide the round-pupilled cats into two genera according to the presence or absence of a first upper premolar. But these characters are too inconstant to serve such a purpose. We have seen that in the lion, even the upper true molar may not only be wanting, but the skull may show no trace of the tooth's past existence. But though the genus *Felis* must be thus extensive, the kinds contained within it may, for convenience, be considered as forming certain sets, distinguished by trivial marks. Thus the male lion, as normally developed, is distinguished from all other cats by its large mane, and the tiger by its vertical stripes and large size. A few, as the puma, jaguarondi, eyra, *F. aurata*, *F. planiceps*, *F. badia*, and *F. rutila*, are separable from the rest by their uniform colour, but the great bulk of the cats are black-spotted animals A few also may be distinguished from the rest as rather "clouded" than "spotted." Such are the *F. marmorata*, *F. macrocelis*, *F. megalotis*, *F. pajeros*, *F. caligata*, *F. Manul*, *F. neglecta*, *F. torquata*, and *F. catus*. Almost every transition, however, exists between the spotted and the clouded cats, and some spotted forms occasionally have their spots very slightly marked, so that generic distinctions reposing on any such characters would be most futile.

Fifty species of living cats have been here enumerated as probably distinct, but it may turn out that certain of these are mere varieties, while some forms here deemed varieties may possibly prove to be really distinct species. It is the South American spotted cats—ocelots and margays—which are specially difficult thus to determine, and with regard to the smaller cats of China, and the adjacent parts of Asia, a similar, though perhaps less degree of difficulty occurs. It may be that *F. Wagati*, *F. javanensis*, *F. microtis*, and *F. Jerdoni*, will have to be merged in other species. Nevertheless it may be considered certain that upwards of forty well-marked species of cats now exist.

§ **14**. A much larger number of species have probably existed in

the past, most of which have disappeared without leaving any yet discovered trace of their existence. Some, however, have left their remains in caves and superficial deposits, while others are made known to us by fossil remains. Indeed, a variety of fossil CATS NOW EXTINCT have been described, but as to many of them there is necessarily great uncertainty, since our whole knowledge of them reposes upon perhaps a lower jaw or one or two teeth. New fossil forms are now being so rapidly discovered in North America, that a complete enumeration of extinct species and a correct appreciation of their affinities must be a work of the more or less remote future. From what is already known, there can be no doubt but that some cat-like creatures, very different from any now living, once existed.

In the first place, a variety of fossils have been found which differ from existing cats in no way that would warrant their being placed in any other genus than *Felis*. Such are cats that have been found in the newer miocene or oldest pliocene of the Siwalik Hills.*

Such, again, are others varying in size from a wild cat to a hyæna, which have been found by Professor Gaudry† at Pikermi in Greece, and many of those which were before described by Professor De Blainville,‡ and by M. Paul Gervais,§ such as *Felis Christolii* (about the size of the Serval).

The great cat known as the so-called "Cave Lion," *Felis Spelæa*,‖ which lived in England in middle and late pleistocene times,¶ is a well known extinct feline form.

But besides these fossils, thus referrible to the existing genus, there are a variety of other remains which cannot be so referred.

§ **15**. Thus the remains of certain large cats have been found in pliocene and miocene, and even in eocene deposits, which differ from any existing cats in the enormous size of their upper canine teeth. The crowns of these teeth were laterally compressed and trenchant, with strong serrations along the margins—a character but feebly developed in any of the large living cats.

Further, the mandible may be widened, from above downwards, the better to protect such enormously developed teeth. These tusks were indeed so large in some species that the jaws could not be opened beyond them so as to allow them to be used for biting. They could therefore only have been made use of as daggers, the animal striking with them with its mouth closed. Such forms must be grouped apart under a distinct generic name—the name MACHÆRODUS. This genus had a very wide range, remains of it having been found in Europe, India, and America, both North and South. In some

* *E.g.*, the *Felis cristata* of Cautley and Falconer.

† See his "Animaux Fossiles de l'Attique," p. 116, plate 17.

‡ Ostéographie. Felis.

§ See his "Paléontologie Française."

‖ Owen, British Fossil Mammals, p. 161; and W. Boyd Dawkins in Palæont. Society, 1869, cxviii.

¶ As to this and other geological terms, see below, Chapter XIV., § 6.

dividuals of this genus, the first inferior premolar may have but ıe root, or may even be wanting altogether, thus carrying the duction of lower teeth to an extreme. In the development of the)per canines the Machærodonts are separated from the general ndition of the cat tribe, not merely in that they were so immense, ıt that their length necessitated a peculiar mode of use, so that

Fig. 184.—Skull of Machærodus smilodon.

hese creatures may be said to have initiated a new and very special modification of cat-existence.

§ **16.** Another fossil form of cat has been named Hoplophoneus* by Professor Cope, who represents it as like Machærodus in having the mandible vertically expanded and the upper canines more or less largely developed, but as differing from it and from all existing cats in that the inferior sectorial has a posterior lobe or "heel," while the superior sectorial has no anterior lobe, such as that which exists (Figs. 12 and 46) in all living cats. Its upper molar is largely developed (Fig. 185, B) and there is no inferior tubercular molar.

It is a miocene genus, founded on fossils from the White Rivers of Nebraska and Colorado.

* See Annals and Magazine of Natural History for January, 1880, p. 39; see also Bulletin of the United States Geological Survey, 7th Report, p. 509; and the Proceedings of the Acad. of Nat. Sc. of Philadelphia, July 8, 1879.

A long known fossil form, PSEUDÆLURUS* (of which several species have been described), is from the upper miocene of France and North America.

This animal had an additional lower premolar, so that there were

Fig 185.

A Skull of *Hoplophoneus oreodontis* Cope). B. Grinding surfaces of right upper molar and sectio

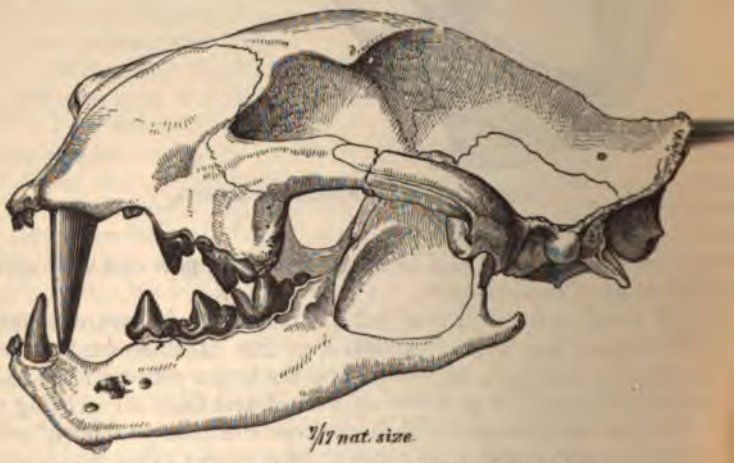


Fig. 186.—SKULL OF *Nimravus brachyops* (Cope), FROM OREGON

three premolars and one sectorial molar in the lower jaw. The lower sectorial has but a rudimentary heel.

* Gervais, Paléontologie Française, p. 232; see also Leidy's Mammals of Nebraska and Dakota in Journal of Academy of Natural Sciences of Philadelphia, vol. vii., p. 52, plate 1, fig. 8; see also Filhol, in Annales des Sciences Géologiques, vol. vii., p. 158. The *Felis quadridentata* of De Blainville belongs to this genus.

§ **17.** Another miocene form (as large as the jaguar) has also been described by Professor Cope, under the name NIMRAVUS. It is from the vicinity of the White River, Oregon. It is described by its discoverer* as having the same form of upper and lower sectorial as *Hoplophoneus*, but as differing from the latter in that it has an inferior tubercular molar. The heel to the lower sectorial is large. The upper canine is very straight and dagger-like, and the alveolar border between it and the second premolar is singularly arched.

A very interesting form, called DINICTIS,† has been found in the

Fig. 187.—SKULL OF *Dinictis Cyclops.*

"mauvaise terre" of Nebraska, which is certainly miocene if not, as some geologists think, eocene. It was as large as the Northern lynx.

In this kind the upper sectorial has no anterior lobe, while the lower sectorial has a very large bifid posterior lobe or heel. The mandible also is somewhat widened anteriorly; but the most interesting character is the presence of a small tubercular molar in the lower jaw, together with three premolars in front of the sectorial, so that there are three premolars and two molars on each side.

Another kind has been described by M. Filhol‡ as *Proælurus*. It has one tubercular molar above and below, with teeth very feline in form. The shape of the skull, however, is not feline, and the present author is disposed to regard it rather as a creature of the weasel kind—an opinion in which he is supported by the concurrence

* Ann. and Mag. Nat. Hist., *l. c.*, and Pro. Acad. Nat. Sc. Philadelphia, *l. c.*

† See Leidy's Mammals of Nebraska and Dakota, Journal of the Academy of Nat. Sc. of Philadelphia, p. 64, plate 5, Fig. 1–4. The genus of *Ælurogale* of Filhol seems to be really the same as *Dinictis*.

‡ See Annales des Sciences Géologiques, vol. x., p. 192, plate 27, figs. 5, 6, 8–13, and plate 26, figs. 2–11; and in the Bibliothèque de l'École des Hautes Études, section des Sc. Nat., vol. xix., 1879, pp. 192–20[illegible]

of Professor Gaudry. It is only therefore here noticed among cat remains,* because Professor Cope appears to regard it as a primæval cat, and it certainly does resemble the cats in the shape of the sectorial teeth, the upper one of which has the internal cusp—which, however, we have seen to be wanting in the living *Cynælurus*.

Fig. 188.—Skull of *Archælurus debilis* (Cope), from Oregon.

§ **18.** A very remarkable miocene fossil, which seems really to have been a kind of primæval cat, is the genus Archælurus of Professor Cope.† This has the usual number of incisors and canines, but has four premolars and a tubercular molar in the upper jaw, and three premolars and two molars in the lower jaw. Its feet are very slender.

The single species of the new genus is described as follows:—"Mandible, with the anterior face of the symphysis, separated from the lateral face by an angle which is not produced downwards. Superior sectorial without anterior lobe;‡ inferior sectorial with a heel. General structure of the jaws, weak; superior canine, small, little compressed, with an acute posterior edge which is not serrulate; first premolar in each jaw, one rooted; second inferior premolar, large; sectorials large; diastemata very short; alveolar border below the inferior sectorial and tubercular teeth everted, forming a large osseous callus, which has a free inferior and posterior margin, the latter rising into the base of the coronoid processes; zygomata slender; post-orbital processes little prominent; front wide, convex transversely. About the size of the panther."

This is certainly the most exceptional and uncatlike of all feline skulls.

* It appears to have had an alisphenoid canal, and M. Filhol regards it as perhaps allied to *Cryptoprocta*. As to these matters, see the chapter on the Cat's place in Nature.

† The American Naturalist for December, 1879, p. 798a.

‡ The upper sectorial appears to have however to have a very large, though little prominent, anterior lobe.

§ **19.** Yet another miocene genus has been described * by Professor Cope. It is named POGONODON, and its skull is about one-sixth smaller than that of the tiger. "The canine is large and compressed, as in *Machærodus*, and has serrulate anterior and posterior cutting edges." The symphysis is much widened to protect the canines. It differs from the Machænodonts in having an additional inferior premolar tooth. The skull of this animal is singularly elongated, and there are three premolars in the lower jaw, while the width of the

Fig. 189.—SKULL OF *Pogonodon platycopis* (Cope), FROM OREGON.

diastema between the upper canine and the first premolar (which is in place) is such as to seem as if another small premolar may have existed.

A very curious and exceptional eocene form of cat has been named *Eusmilus*.† It differs from all other known felines in having only four incisors in the lower jaw, and a pair of small canines separated by a very long diastema from the next teeth, which consist only of one premolar and one sectorial true molar. The lower jaw is enormously widened towards its symphysis to protect the large upper canines. It represents the characters of a flesh-eating, predacious animal of the cat-kind, carried out to an extreme degree. Professor Cope considers EUSMILUS as forming the culminating development of the Machærodont type of structure (Fig. 190).

§ **20.** A genus named *Ælurodon*, has been founded by Professor Leidy ‡ on an upper sectorial tooth found by Dr. Hayden at the Loup River, Nebraska. It closely resembles the corresponding tooth of the cheetah in the abortion of the internal cusp.

A genus termed *Limnofelis* has been instituted § to designate

* See the American Naturalist for February, 1880, p. 143, and for December, 1879, p. 798.

† By M. Gervais in the 2nd part of his Zoologie et Paléontologie Générales, 1876, pp. 53 and 54, plate 12. See also Filhol, Recherches sur les Phosphorites de Quercy, Ann. des Sc. Géologiques, vol. viii., 1877, *p. 321, and vol. vii., 1876,* p. 153, plate 28.

‡ Journal of the Acad. of Nat. Sc. of Philadelphia; Mammals of Nebraska, p. 68, plate 1, figs. 13 and 14.

§ American Journal of Science and Arts, vol. iv., August, 1872. See also Silliman's Journal, 3rd series, vol. iv., 1872, p. 202.

an extinct form which was as large as the lion. Certain portions of the skull and of the mandible, with the lower sectorial, have been more or less preserved. The description, however, as yet published is too incomplete to admit of its place in the cat series—supposing that it really has a place there—being determined.

The name *Trucifelis** has also been imposed on an upper sectorial tooth, which is more like a cat's milk sectorial tooth than it is like the permanent sectorial. It cannot therefore as yet, any more than *Limnofelis*, be admitted as a recognised extinct member of the cat group of animals.

Our knowledge of the kinds which have been reckoned as distinct species (*i.e.*, of the species of the various fossil genera) is too frag-

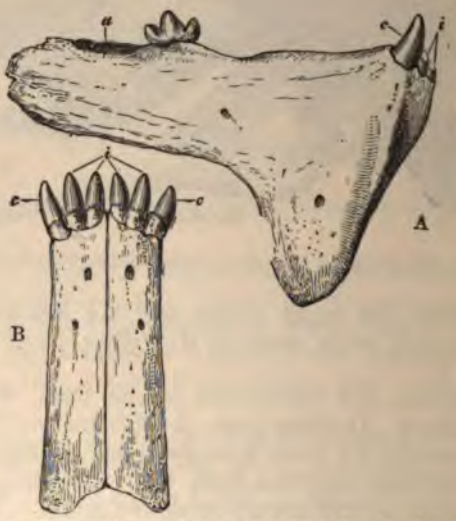


Fig. 190.—Part of Lower Jaw and Teeth of *Eusmilus bidentatus*.

A. Right side of mandible.
a. Socket of lower sectorial.
c Canine.
i. Incisors.

B. Under surface of anterior end of mandible.
c. Canine.
i. The four incisors.

mentary to admit of their enumeration, alongside of existing kinds, as of equal value. Some four species of *Dinictis*, five of *Pseudælurus*, three or four of *Hoplophoneus*, two of *Pogonodon* and two of *Nimravus*, and at least eleven of *Machærodus* have been described.

It is not possible to arrange the extinct and existing genera in one series, but if the cheetah (*Cynælurus*) and *Ælurodon* be left out, the rest may perhaps be arranged on either side of *Felis* (according to their affinities to it and to each other) in the following order:—

1, *Archælurus*. 2, *Dinictis*. 3, *Nimravus*. 4, *Pseudælurus*. 5, *Felis*. 6, *Hoplophoneus*. 7, *Pogonodon*. 8, *Machærodus*. 9, *Eusmilus*.

* By Professor Leidy, l. c., plate 28.

)f existing cats, it is the clouded tiger (*F. macrocelis*) which
t resembles *Machærodus*, not only by its very long upper canines,
also by the shape of its skull. *Felis planiceps*, with its large
er premolar, shows a certain affinity towards fossil forms which
e more developed premolar teeth than have any of the exist-
cats.

As to the fossil cats, in addition to the structural facts already
ntioned, it is important to note that *Archælurus*, *Dinictis*,
nravus, *Pogonodon*, and *Hoplophoneus* agree in differing from all
sting cats (and from other fossil cats, so far as has been yet ascer-
ned) in that the carotid and condyloid foramina open separately
n the foramen lacerum posterius, and in that the ali-sphenoid
elops a lamina of bone to embrace the external carotid artery,
aperture left for the artery forming what is called an *ali-sphenoid*
*al.** In these respects, however, *Machærodus smilodon* resembles
sting cats.

It is abundantly evident that the differences between any of the
cies which now live are very small compared with those which
arate such forms as *Archælurus* and *Eusmilus* from existing
cies or from one another. It is the two last-mentioned genera,
ether with the sabre-toothed Machærodonts, which exhibit to us
most extreme and divergent structures as yet discovered, amongst
e various widely spread, or long existing, forms of animal life
ch can make a valid claim to be considered as belonging to the
t feline group—to be, in fact, some amongst the various "kinds
ats."

* These facts are mentioned by Pro- Cope (see "American Naturalist," mber, 1880, pp. 834 and 835) in a which has only reached my hands ese pages are passing through the . On account of the differences in cranial foramina, Professor Cope es the cats into two families: elidæ; II. Nimravidæ. But the itions in this respect presented by *dælurus* and *Eusmilus* have not yet described. Moreover, while disposed to admit the claim of *Archælurus* to rank as a distinct sub-family did it stand alone, it seems to me that *Dinictis*, *Nimravus*, *Pogonodon*, and *Hoplophoneus* go far to bridge over the differences between it and the other cats, and I cannot regard the two last-named genera as deserving to be ranked in a sub-family distinct from the bulk of the Felidæ. How exceptional is not *Otocyon* amongst the Canidæ!

CHAPTER XIII.

THE CAT'S PLACE IN NATURE.

§ 1. NOTHING can be understood by itself. All our knowledge consists of apprehensions which have been acquired by comparing and contrasting one thing with another; and the more we know of any object, the greater is the number of relations we are able to affirm to exist between it and other objects. To fully understand any living creature, then, we should understand, as far as we can, the various relations in which it stands to all other living creatures: More than this, we should also understand its relations with that part of the creation which is devoid of life—in short, we should understand "*its place in nature.*"

But the reader may deem such an inquiry superfluous as regards the animal which we have elected to study; for any one who is asked, "What is a cat?" will at once reply "A beast of a certain kind which preys on other animals;" and if again asked "What is meant by a beast?" will probably say, "a living four-footed animal." If, however, the inquiry be pressed further, and precise meanings of "living creature," "animal," "beast," and "beast of prey," be demanded, the unsatisfactoriness of mere vague, popular conceptions will be plainly shown. We must then endeavour to obtain a full, clear, and precise knowledge of what is, or should be, meant by the above terms, so that we may be able to answer the question, "WHAT IS A CAT?" with accuracy, and with a sufficient comprehension of the expressions employed in so answering. We must know "the why and the wherefore" of the terms of our answer.

§ 2. Now, in the first place, we have seen that the body of the cat is bounded on all sides by curved lines and surfaces. Secondly, we have recognised that its body consists of different organs and tissues, and that wherever we may cut through it, we come upon parts which differ one from another—its body, therefore, is anything but homogeneous. A third fact about the cat's body concerns its chemical composition. We have seen that a great uniformity exists in this respect, and that all the main portions of it—its flesh, its nerves, its blood, &c.—are reducible to oxygen, hydrogen, carbon, and nitrogen, of which (with the addition of a minute quantity of

few other elements) the whole cat may be said to consist. We ave also seen that these chemical elements are built up into rganic substances of very complex nature (the various albuminous ubstances) which make up its flesh and blood, its nerves, &c.

So much for facts of *structure*. As regards *function*, there are everal of the cat's activities to which attention must here be edirected. The kitten grows, and the adult cat continually uses up nd replaces, in the wear and tear of life, different parts of its ubstance. Both these kinds of "growth" take place, as we have en, not upon the surface of the body—internal or external—but the very inmost substance or parenchyma of that body, by a rocess of "intussusception."

But growth needs the presence of certain conditions without hich it cannot take place, because life itself cannot be maintained ithout them. The cat, like ourselves, can endure considerable anges of temperature, but there are temperatures which it cannot ng endure and live—such as much below 32° Fahr. on the one nd, or near 212° Fahr. on the other. Again, moisture is a ecessity to it, for a very large part of its body consists of water, and a perfectly dry atmosphere its existence would soon come to an d. Besides these conditions, the process of intussusception is not ly one which the cat can carry on, but one which it *must* carry on it would continue to exist—the taking in of food is a positive cessity for such existence. But this food, as we have seen, is rtly gaseous, and the animal does not take in one gas at its lungs thout at the same time giving forth another in its place. There going on, in fact, a process of "gaseous interchange," and without e continuance of such a process the cat could not itself continue to . Finally, we have recognised that the cat-life may be described as cycle of changes. Let there be a proper supply of food and good air, th sufficient warmth and moisture, and the kitten becomes a cat, hich again reproduces (the requisite conditions existing) a kitten. very cat, then, possesses an innate tendency to carry on a cycle of finite and regular changes when exposed to certain fixed conditions.

§ 3. In the structural and functional characters above given, e cat agrees with all other living creatures, and DIFFERS FROM EATURES WHICH ARE DEVOID OF LIFE. All living creatures, not only animals, but all plants down to the lowest fungus or alga, agree th the cat in possessing an innate tendency to carry on cyclical anges; the flower becomes a fruit, whence comes a new plant, hich produces a flower again, and grows by intussusception. All ed moisture and a certain moderate temperature* for their con- nued existence, and all both feed and carry on a process of gaseous change with the medium which surrounds them. All consist rgely of oxygen, hydrogen, carbon, and nitrogen—built up into otoplasm—almost all are bounded entirely by curved lines and

* It is suspected that the germs of me lowly organisms may fail to be destroyed by exposure to a temperature of 300° Fahr.

surfaces, and all possess a heterogeneous section, for even the lowest animalcule, when cut through, shows that it is composed of a semi-fluid substance through which granules are diffused.

On the other hand, crystals, and many minerals, present a homogeneous surface when cut through, being perfectly alike throughout their entire substance. A few minerals, such as spathic iron and dolomite, are, indeed, bounded by curved lines and surfaces; not only, however, can no such character be affirmed of minerals generally, but the whole multitude of crystals are actually classified according to the angles formed by the plane surfaces which bound them on all sides. No such uniformity of chemical composition, again, can be affirmed of minerals, as of living beings, nor are their elements built up into protoplasm. It is true that crystals will grow: Suspend a small one in a suitable fluid and it will become a large one; break off the angle of a crystal, and, similarly suspended, it may replace the part removed by a fresh growth. But such growths (unlike those of the cat and of all living creatures) are not brought about by internal increase, but by a mere superficial deposit. Many mineral substances persist unchanged during variations of temperature very far exceeding that between 32° Fahr. and 212° Fahr. Many, also, can persist in a perfectly dry atmosphere, since they need no moisture whatever. Such processes also as those of food-taking and continuous gaseous exchange, are unknown in the non-living, inorganic world. Finally, no mineral whatever possesses an innate tendency to carry on a cycle of definite and regular changes when exposed to any given conditions. A crystal may, indeed, be artificially broken up into smaller crystals, which, if suspended, as just mentioned, will grow externally, and may be again artificially broken up, and so one crystal may be made to produce others. But such an action is altogether different from organic reproduction. No non-living creature reproduces through an innate power, as every living creature does, or tends to do.

We see, then, what we implicitly affirm when we say that the "cat" is "a living creature," and we may now apprehend certain very general and important contrasts which exist between it and the whole inorganic or lifeless world.

§ **4.** But an objection may perhaps be made to the above representation, as follows: "upon the theory of evolution, living beings first arose spontaneously, in a world which, according to the view just stated, would be a world devoid of life. But the law of continuity forbids the sudden appearance of any phenomenon: therefore life must have really somehow existed in such a world, and therefore there is no such distinction between the living and non-living as that above given." This objection might be re-enforced by the following argument: "Your cat gives forth ova and spermatozoa; these bodies exhibit such movements and actions as certainly imply that they are alive. Yet they do not exhibit the main characteristic above given of living things—for they do not tend to carry on a cycle of changes when exposed to certain fixed conditions.

der no circumstances will ova directly reproduce ova, or sperma-
oa, spermatozoa. Such bodies are in this respect like the first living
ature, which spontaneously arose. At that early period the earth's
dition was such as to favour spontaneous generation, and there-
e no reproductive agency was needed beyond that which naturally
sted in the matter whence such organisms sprang. They therefore
ther needed nor possessed reproductive power. Only with the
ing away of this earlier terrestrial condition were such creatures
began to possess a reproductive capacity favoured in the struggle
life, and thus by degrees reproductive power became first frequent
organisms, then general, and now universal."

Let us consider first the argument by which the above objection
s been re-enforced. To it we may reply: Great as is the difference
tween a cat and a cat's ovum or spermatozoon, yet if the whole
imal series is considered, a variety of forms will be met with
which larger and larger portions of what we justly take to be
ue animals are thus detachable and detached. Indeed, at last we
me to creatures * in whom the cycle of life is, as it were, so split
, that it is difficult to say which of the creatures that successively
pear between one fertilised ovum and another, is to be reckoned
the more perfect animal. Yet all these creatures are living, and
tend to carry on a definite and regular cycle of changes when
posed to certain fixed conditions. The very same, then, may be
d of the cat's ovum or spermatozoon. Like the intermediate
ms of the life cycle of many lowly creatures, they also, though
ey do not *themselves* tend to "undergo" the whole cycle of changes,
possess an innate power and tendency to initiate, produce, and
arry on" that cycle in which they themselves play an important
rt, and by which their own forms *are* indirectly reproduced.
herefore there is no real parity between these elements and
pothetical primordial animals, naturally altogether devoid of
nate reproductive capacity. No such creatures are known to exist
w. To believe that such ever existed would therefore (in the
sence of any positive evidence of their past existence) be at once
th gratuitous and contrary to experience; yet experience is the
mitted source of all our knowledge!

Having disposed of the re-enforcing argument, we may now con-
ler the original objection itself. This objection is the real ground
on which a belief in the original existence of non-reproductive living
ings rests, namely, an *à priori* necessity reposing on a now pre-
lent conception as to the "law of continuity." That law, we are
d, "forbids the appearance of any new phenomenon." We reply
so much the worse for that law. The existence of breaks, gaps,
d new beginnings, is a manifest truth which cannot be denied
cept by playing tricks with language—using words in non-natural
ses—and by ignoring the differences and paying attention only
the resemblances which exist between different things. The

* *E.g.*, certain jelly-fishes, certain tunicates, and certain worms.

foolishness of this kind of reasoning will not really be exaggerated if it is represented by an argument such as the following patently fallacious one: "A cat is an entity, a dream is an entity, therefore a cat is a dream."*

* This folly is well pointed out by the late G. H. Lewes, in the second chapter of the second problem of his third series of 'Problems of Life and Mind.' He says: "Psychologico-metaphysical speculation, untrammelled by the distinctions of sensible experience, easily arrives at Panpsychism. The hypothesis rests upon an arbitrary extension of terms, and upon an exclusive selection of one order of conceptions. By a sufficient elasticity of terms we may easily reduce all diversities to identity; all things are alike if you disregard their points of unlikeness. . . . Stretching terms, it is easy to identify life with molecular change, and then conclude all things to be living. But the biologist must protest against such manipulating of conceptions. For him life expresses a vast class of phenomena, never found except in definite groups of substances, undergoing definite kinds of molecular change. The crystal is not alive, because it does not assimilate, reproduce itself, and die. . . . Any one choosing to stretch terms may say that molecules live because molecules exist. But in that case we shall have to create a new term for the mode of existence, which is now called life. . . . Playing such tricks with language, we may ask: Why should not a lamp-post feel and think, since it is subject to molecular changes consequent on impression? Why should not a crystal calculate? Does not oxygen *yearn* after hydrogen? Has not hydrogen the property of humidity? These questions seem absurd, yet they are only naked presentations of what some philosophers have clothed in technical terms, and their readers have accepted with confidence. . . . And why this reliance on the law of Continuity? That law is simply a deduction from the conception of Quantity, abstracted from Quality by mathematical artifice; it is one abstract idea of existence irrespective of all concrete modes of existence. It has its uses; but note, first, that it is an ideal construction, not a real transcription; secondly, that not only is it an ideal construction, which once formed becomes a necessity of thought, although it is detached from and contradictory of real experiences, it is also in the very nature of the case only applicable to abstract existence; and not to concrete modes of existence. See how these considerations nullify the application of the law to the gradations and diversities of organic phenomena. If Continuity is a necessity of thought, not less imperiously is Discontinuity a necessity of experience, given in every qualitative difference. The manifold of sense is not to be gainsaid by a speculative resolution of all diversities into gradations. Experience knows sharply-defined differences, which make gaps between things. Speculation may imagine these gaps filled, some unbroken continuity of existence linking all things. It *must* imagine this, because it cannot imagine the non-existence coming between discrete existences. . . . Turning from the metaphysical to the biological consideration, it is plain that the characteristic phenomena observed in organisms are not observed in anorganisms; and even in cases where a superficial appearance seems to imply an identity, an investigation of the conditions shows this not to be so. The actions of a machine often resemble certain actions of an organism. But when we come to understand how both are produced, we understand how the products are really very different. We deny that a crystal has sensibility; we deny it on the ground that crystals exhibit no more signs of sensibility than plants exhibit signs of civilization; and we deny it on the ground that among the conditions of sensibility there are some positively known by us, and these are demonstrably absent from the crystal. It is in vain to say sensibility depends on molecular change, therefore all molecular change must in some degree be sentient change; we have full evidence that it is only special kinds of molecular change that exhibit the special signs called sentient; we have as good evidence that only special aggregations of molecules are vital, and that sensibility never appears except in living organisms, disappearing with the vital activities, as we have that banks and trades' unions are specifically human institutions. On the first head; that of evidence, we must therefore pronounce against the hypothesis of panpsychism. How about its philosophic advantages? To some minds eager for unity, and above all charmed by certain poetic vistas of a cosmos no longer alienated from man, the hypothesis has attractions. But while its acceptance would introduce great confusion into our

ut because the plain evidence of our senses compels us to deny life actually exists or ever did exist in non-living matter, it o means follows that life was not *potentially* present in it. But tential existence" is not "an actual existence of a latent kind." expression merely means that conditions exist in matter such that he action upon it of influences external to it life will arise within life not previously present in a latent state, either in the matter n the influences the action of which on matter produces it. Con- uently a belief in such spontaneous generation in no way destroys greatness and sharpness of the distinction which exists and must ays have existed between the living and non-living worlds.

5. The contrasts which exist, then, between the cat, CONSIDERED ELY* AS A LIVING BEING, and the mass of non-living inorganic gs may be summed up as follows:

1) It is bounded by curved lines and surfaces.
2) Its section is heterogeneous.
3) It consists almost entirely of oxygen, hydrogen, carbon, and nitrogen, and largely of protoplasm.
4) It grows by intussusception.
5) It needs a certain moderate heat.
6) It needs definite supply of moisture.
7) It needs food.
8) It effects a process of continued gaseous interchange.
9) It tends to carry on a cycle of changes when exposed to certain fixed conditions.

6. We have next to consider what we imply when we say that e cat is an ANIMAL."

ery obvious are the characters which distinguish it from plants erally. It is actively locomotive, possesses feelings and in- gence, is of a very different shape, never reproduces by budding, in feeding, it takes its food into an internal † cavity, its

eptions, and necessitate a completely nomenclature to correspond with the lished conceptions, it would lead r to a vague mysticism enveloping hings in formless haze, or to a change rms with no alteration in the con- ons. By speaking of the souls of molecules we may come to talk of molecules as men 'writ small;' we assign our controversial passions to orrent, and our dogmatic serenities e summer sky; we shall see volition ie magnet, and contemplative effort orphological changes. If we escape and regard the life and sentience of anic bodies as only the lowest and lest stage of consciousness, indis- tishable from what we now call n except that it has an infinitesimal tity of consciousness; and if from anic bodies we pass to simple organ- from these to organisms more and complex, the soul enlarging with stage of evolution; well, then we are returned once more to the old point of view; the broad lines of demarcation, which our classifications fix, remain undisturbed, and all the modes of existence known to science are recognised as such. Into this scientific system the metaphysical conception of uniform existence has obtruded itself and borrowed scientific terms; but the obtrusion is a confusion, not an illumination."

* "Merely as a living being," because of course a practically infinite number of distinctions exist between such an animal as the cat considered *by itself*, and non-living creatures, *e.g.*, no mineral has hair, or a brain, &c.

† A cavity, that is, *practically* internal, for in fact, as we have seen, the cat's stomach being but a prolongation inwards of its exterior, is "morphologically" outside the animal. The space within each pleura or within the peritoneum is *really* internal.

stomach, where it is digested. Moreover, if we analyse th tissues we shall find they are almost all nitrogenous, such as nerve, and blood, whereas plants, though containing protopla largely consist of a non-nitrogenous substance termed "cel and contain much starch. But we have to seek for dist between the whole world of plants, and the cat considered as an animal, and therefore for such distinctions as al animals share with it. Now the above given distinction motor power, sensitivity, external form, mode of reproc manner of feeding, and chemical composition, serve very distinguish the bulk of animals from the bulk of plants, but w come to examine the most lowly organised plants and anin these distinctions seem to fade away.

Thus, with respect to motor power, very little difference perceived between some of the lowest aquatic animals and both of which may be compared to a detached fragment of t ciliated epithelium, since they consist of a few cells which p protoplasmic threads, the lowly organism propelling itself al the lashings of such threads. Other animals of considerabl plexity of structure—such as some of the Tunicates—adhere t and appear quite motionless, save when touched, and the eject water from two apertures, thus showing a motor powe parable with that of the squirting cucumber. But there are still more inert, such as the bladder-worms, or hydatids, wh hidden in the flesh (or other parts) of the animals they infe which are little more than small membranous bags enclos albuminous fluid. On the other hand, various plants show co able motor power, such as the sensitive plant, Venus's fly-tr others.

The last named organism serves to show us also that degree of impressionability may be present in plants, thou have certainly no evidence that any of them possess "fe But a multitude of the lowest animals seem to exhibit no mo of sensibility than do the lowest plants. The hydatids, just to, may serve as an extreme instance of such apparent insen Hydatids, however, are creatures in an imperfect stage c development, the adult stages of which (tape-worms) do give e of a power of sensation. So that sensitivity may be pot present in these hydatids as it is in the cat's ovum, which ce itself, gives no evidence of, nor can be supposed to posse actual power of feeling. On the other hand, such plant-mov as those referred to, are explicable in an altogether differe from the sensori-motor movements of animals, while we h ground for attributing to them potential sensibility, since u conditions does it ever become unequivocally actual.

As to external form, no distinction can be drawn between the lowest algæ or fungi on the one hand, and the lowest ani the other, whilst many zoophytes and some other animals, the branching mode of growth common in plants; while some

as the melon cactus, are not arborescent, but assume a spheroidal figure.

As to modes of reproduction, no absolute distinction can be drawn between plants and animals. For many animals reproduce by budding (as do zoophytes), and some may even be propagated by cuttings. Thus if the *Hydra*, or the common sea-anemone (*Anthea*), be bisected, each half soon grows into the perfect form once more, and many worms (such as *Scyllis* and *Catenula*), and animalculæ called *Infusoria*, habitually multiply by self-made sections, *i.e.*, by spontaneous self-division or "fission" Not only, moreover, is sexual reproduction as universal amongst plants as amongst animals, but even male mobile filaments, closely resembling spermatozoa, are developed by very many flowerless plants.

As to the different modes of feeding practised by plants and animals, imbibition is indeed (as has been said) universal with the former. But then the digested insects made use of by *Drosera* and *Dionæa* may be said to be taken into a temporary quasi-cavity, while in certain other plants the receptacle has the form of a permanent sac. This is the case with the curious pitcher plant (*Nepenthes*), in the pitchers of which insects are caught and decomposed, probably to the profit of the plant.* But not all animals take solid food into an internal cavity or stomach. Many can only imbibe it through the outer surface of their bodies. It is thus that tape-worms (which lie perennially bathed in a fluid medium unceasingly nutritious) feed.

Lastly, we come to the distinction between animals and plants as regards their chemical composition. Now it is true that most plants are less nitrogenous than are animals. But this cannot be affirmed of the great group of Fungi. Moreover, substances which were long deemed peculiar to the vegetable kingdom, are now known not to be so. Thus, "starch," *e.g.*, has been found even in the human brain; while "cellulose"—the principle of wood—exists in the tough external coat which invests the bodies of the Tunicates before referred to.

Thus all the foregoing six distinctions break down with respect to a considerable number of animals or plants, though they may serve to separate all the higher forms of the two kingdoms of living beings.

Other distinctions, however, exist which have a greater value, and may be conjointly made use of in discriminating almost all plants from all animals. Of these there are two—the first (A) relates to structure; the second (B) relates to function.

A. It has been already said that every living organism consists of a substance called protoplasm, with which other substances (some nitrogenous, some non-nitrogenous) may co-exist. Amongst the non-nitrogenous occasional accompaniments of protoplasm is "cellulose."

* The structures referred to are curious pitcher-like productions which are formed at the end of foliage leaves.

Now, all plants, except the very lowest, have their constituent protoplasm divided into a number of minute separated parts (or cells), each such separated part being enclosed within an envelope of cellulose. But in no animal whatever does this obtain.

There are, however, lowly animals and plants which consist each of a single particle of protoplasm, but almost all unicellular plants are enclosed within a cellulose envelope—an investment which is wanting in such lowly animals. In regard to structure then, we have thus an almost complete distinction between all animals and almost every single plant.

B. As regards *function*, there is a still more important distinction. The cat's body is, as we have seen, reducible to a certain number of chemical elements. Let a living cat be supplied with these same elements, in whatsoever combinations artificially produced, and in the greatest abundance, and the animal will none the less starve to death, however much it may eat of such substances. For the cat possesses no power of building up its tissues from inorganic matter, but absolutely needs for its subsistence a food consisting of organic matter already formed. It may be said that such is the case because the cat is a beast of prey. But it is the very same thing with the mice, young rabbits, or grain-eating birds, on which the cat may live. None of these vegetable-feeding creatures can, any more than the cat, live upon the inorganic world exclusively. Nor can other animals, however lowly, do so, for though a few worms have an exceptional power in this respect, yet even they also feed, like other animals, upon organic matter. Thus it may be affirmed that the cat agrees with every other animal in not being able to sustain itself by forming living matter (or protoplasm) from the inorganic world alone. With most plants it is far otherwise, they can live upon inorganic matter only, and have the power of dissolving the carbonic acid of the atmosphere, and retaining its carbon while letting its oxygen go free.

It is by the exercise of this power that all the wood which exists, and all coal (which once existed as vegetable substance) have been produced. Still, not all plants possess this power; for the group of fungi, together with such parasitic plants as are devoid of green foliage leaves, require, as animals do, organic matter for their food, and have not the power of thus fixing carbon.

The cat then, inasmuch as it is an ANIMAL at all, differs from almost all PLANTS:—

(1.) In that it needs organic matter for its food, and

(2.) In that the protoplasm of its body is not enclosed or partitioned by a structure of cellulose.

But in that it is not an animal of a lowly kind, it further differs from almost all plants:—

(1.) In its power of locomotion;

2.) Its sensitivity;

(3.) Its non-arborescent external form;
(4.) Its incapacity for reproducing its kind by a process of budding;
(5.) Its habit of receiving its food into an internal cavity, and
(6.) The more nitrogenous nature of most of its tissues.

As to the points in which the cat *resembles* plants, it of course agrees with them in all those characters by which it is distinguished from non-living, inorganic matter. It also further agrees with all plants, and also with all animals, in that at one stage of the cycle of life it is represented only by a minute spheroidal mass of protoplasm —the ovum or germ.

§ 7. The cat having been thus compared with the inorganic world, and with the world of plants, our next endeavour should be to ascertain its POSITION AMONGST ANIMALS. To be able to do this, however, it is necessary to be acquainted with the mode in which animals are classified; for the number of their kinds is so prodigious that it would be perfectly impossible to comprehend them without the assistance of a well-arranged SYSTEM OF CLASSIFICATION—a system which may enable the student to conceive of different animals in masses, such masses being arranged in a series of groups, successively smaller and more and more subordinate. Animals, like plants, are considered as members of one great group, which has been fancifully termed a "kingdom"—the *animal kingdom* containing all animals, as the *vegetable kingdom* contains all plants. The principles adopted by both zoologists and botanists in subdividing these "kingdoms" are "morphological." By this term it is meant that the characters upon which these classifications repose, and by which the various subordinate groups are defined, are characters taken from the shape, number, structure and mutual relations of the parts of which the various creatures so classified are built up, and not upon what such parts *do*—the characters refer to "structure," not to "function."

The kingdom of animals is divided into a variety of *sub-kingdoms*, each of which is, of course, a very large group of animals indeed. Each sub-kingdom is again divided into subordinate groups termed *classes*. Each class is again divided into *orders*. Each order is further subdivided into *families*; each family into *genera*, and each genus into *species*; while a zoological "species" may be provisionally defined as "a group of living organisms which differ only by inconstant or sexual characters." Sometimes, when a family contains a great many genera which differ one from another in such a way that they can be arranged in sets, then the term "*sub-family*" is given to each such set. Similarly, different sets of families may be grouped together (it may be only one family in one set and the rest in another), and then the term "*sub-order*" is employed to denote each such set of families. Similarly here and there the term "*sub-class*" may be conveniently employed for groups of orders, and lastly, sets of classes may sometimes be conveniently united as a *province*. Thus in one sub-kingdom we may merely meet with classes, orders, families and genera, while in another we may meet with provinces, classes, sub-classes, orders, sub-orders, families, sub-

families and genera. Each of these groups is in all cases defined (as before said) by the common structural characters which the creatures included within it possess. The groups become successively smaller and smaller (in the number of species they contain) as we descend from any sub-kingdom through its classes and orders to its families and genera. In other words the groups become successively smaller in their *extent*. In each case the technical name given to a group *denotes* the animals contained within it, and *connotes* the common characters which pertain to the group. Obviously then, the larger and more primary the group, the greater the number of kinds denoted by it (*i.e* the greater its *extension*), and the less the number of common characters connoted by it (*i.e.* the less its *intension*). Obviously also, the ultimate groups, *e.g.* "species," have the least extension, but imply, or connote, the greatest number of common characters, *i.e.* they have the maximum of intension.

§ 8. Now the animal kingdom (as generally understood) is divisible into eight sub-kingdoms, apart from that to which the cat belongs. Thus there is the sub-kingdom (I.) HYPOZOA, which includes all the lowest, so called, animals, such as Amœbæ, Foraminifera, Radiolaria and Flagellate animalcules—together forming the Rhizopoda—with the lowly parasites called *Gregarinida*, and all Infusoria. (II.) Secondly, there is the sub-kingdom of Sponges, SPONGIDA. Next comes (III.) the sub-kingdom which includes the Hydra and Sea-anemone, together with all Jelly-fishes, Sertularians, coral-animals and such creatures as Beroë and the *Cestum Veneris*. This great sub-kingdom is that of the CŒLENTERA. Then there is (IV) the sub-kingdom ECHINODERMA, which includes the star-fishes, sea-urchins (or sea-eggs), brittle-stars and the sea-cucumbers, some of which are known as the Japanese edible "Trepang." Next (V.) comes the very numerous sub-kingdom of Worms, VERMES, amongst which are to be reckoned not only earth-worms, leeches, sea-mice and tube-worms—these four forming the *Annelids*—together with tape-worms and thread-worms; but also the flukes (or *Trematoda*), the *Turbellaria*, the *Bryozoa* (or *Polyzoa*), the wheel-animalcules (or *Rotifera*), the singularly primitive worm *Dicyema*,* together with *Balanoglossus* (type of the *Enteropneusta*) and the active marine *Sagitta*, with worms allied to the Echinoderma and called *Gephyrea*. Then we have (VI.) the sub-kingdom ARTHROPODA, largely exceeding, in the number of its species, all other sub-kingdoms put together. It includes the crabs, lobsters and shrimps, the centipedes and millipedes, the spiders, scorpions, ticks and mites, and all the vast multitude of Insects. We have also (VII.) the sub-kingdom MOLLUSCA, containing all the cuttle-fishes, pteropods, snails and whelks, oysters, scallops, &c., with the curious lamp-shells. Lastly we have (VIII.) the sub-kingdom TUNICATA, containing the seemingly senseless forms already noticed as Tunicates, with a number of other species; all of which are often called Ascidians.

* Described by Prof. E. Van Beneden, Bull. Acad. Belg. xli., xlii., 1876, "Recherches sur les Dicyemide." It may be the type of a distinct sub-kingdom.

Let us now revert for a little time to some of the facts we have eviewed as to the cat's structure, selecting certain characters for reasons which will shortly appear,) and viewing them in the nost general way. We have, in the first place, seen that the cat's supreme and governing set of organs, the central part of the nervous system, runs along the back of the animal enclosed in a special tube, which is separated from the more ventral part of its body by the vertebral centra. We have also seen that the central part of its circulating system lies above its sternum in the ventral part of its body, with the alimentary canal running between it and the spinal column. The anterior end of that canal we have also seen to end at the mouth, which is placed on the ventral side of the brain. The limbs we have noted as consisting of two pairs, neither more nor less, each supported by a solid internal skeleton. No prolongation, however, of the body cavity or of the alimentary canal enters any of the limbs. We have also seen that its blood is red, and that a portion of the blood, on its way back to the heart, undergoes a secondary, "portal," circulation in the liver. The mouth we have found to be bounded by jaws placed one above, the other below—and not laterally, or right and left. In development we have recognised that the first sign of the embryo is a longitudinal groove, beneath which a "chorda dorsalis" is formed, while visceral clefts and arches are temporarily developed on each side of the pharynx—the visceral arches taking part in the formation of the jaws. The above characters are characters all of which the cat shares with a certain number of animals not yet here referred to; namely, with fishes,* frogs, and toads, reptiles, birds and beasts, and lastly, with ourselves also. These creatures together make up another (the ninth and last,) sub-kingdom of animals, the sub-kingdom VERTEBRATA—so called because all the creatures which belong to it possess a spinal column, or backbone, made up in most cases (as we have seen it to be in the cat) of a chain of spinal bones or vertebræ. The cat then is one of the group (sub-kingdom) of "backboned animals." All these vertebrate creatures possess a fundamental agreement in organization with the cat, though, as we shall see, they present various and very different degrees of minor structural divergence from it. But the creatures which belong to the other eight sub-kingdoms, though they greatly vary *inter se*, yet all agree to differ fundamentally from the type of organization presented by the Vertebrata. On this account they are often conveniently spoken of as one whole, under the name *Invertebrata*—although they cannot be united into one group by any positive characters which are not applicable to all animals whatsoever. That we may be able the better to appreciate, by contrast, the value of these vertebrate characters which thus exist in the cat, —the presence of which is implied when we say that the cat is a backboned animal—it may be well to shortly glance at the organization of one or two of the Invertebrata.

* There is one fish (the Amphioxus or lancelet) which is much more lowly organized than any other vertebrate animals —as will be pointed out later on.

Taking then the *Lobster* as an example of the *Arthropoda*, we find it to be a creature the body of which is different indeed from that of a beast, bird or fish. Instead of an internal skeleton, we find it has a skeleton which is external. Moreover the calcareous portions of this external skeleton are moved (as so many levers, one upon another) by muscles, as in the cat, but then these muscles do not, as in the cat, clothe the skeleton externally, but are enclosed within it. Instead of a body the segmentation of which only reveals itself internally (by the backbone and ribs), and which is but slightly manifested externally (by at most two pairs of serially homologous limbs), we find in the lobster a body consisting in great part of externally visible segments, which it is plain are serially homologous, and which are provided with numerous pairs of limbs, which are also serially homologous one with another. Instead of a pair of jaws biting vertically, and derived from special modifications of the body-wall—*i.e.*, from the visceral arches—we find a number of jaws arranged in pairs and biting laterally, and which are really limbs modified in a special manner. Instead of a frame made up of two super-imposed cylinders, with the circulating centre ventral and the nervous centre dorsal, we find a frame consisting of a single cylinder, with the heart placed dorsally and the central part of the nervous system extending from before backwards on the ventral side of the single cylinder—while there is nothing answering to the cat's spinal column. Again, in the lobster the alimentary tube, instead of bending away from the nervous centres at its anterior end, not only bends towards them, but actually traverses them. There are arteries and veins, but there is no portal circulation. The organs of sense are also very different from the cat's. The lobster has indeed a pair of eyes and also a pair of ears, but these are situated on, or in, modified limbs and not in the head, and the eyes have not various parts which exist in the cat, while the rods and cones of the retina are placed at the surface and not at the deepest layer of that membrane. In development, we have no such medullary groove, becoming a tube, as in the cat (though the nervous centres are still formed from epiblast,) nor do visceral clefts or arches ever arise; moreover it is the ventral, not the dorsal, surface of the embryo which first appears.

As the type of another sub-kingdom, that of the *Mollusca*, we may select the *Cuttle-fish*, which exhibits a form as different from the cat, as is that of the lobster, but also one as different from that of the lobster as it is from that of the cat. For the cuttle-fish has a large soft body, destitute both of the hard envelope of the lobster and of the internal, axial and appendicular skeleton of the cat, and consisting of a fleshy bag, at one end of which is a head, with a pair of large eyes and ten fleshy processes, or "tentacles," radiating from the terminal mouth of the bag. The body shows no serial segmentation, either externally, as does the lobster, or internally, as does the cat. Neither does it show, like both these animals, an elongated nervous axis, but instead, certain nervous ganglia (whence

erves radiate,) aggregated near the mouth and surrounding the limentary tube. It has eyes, indeed, which are very like the cat's, et the rods and cones of the retina are placed as in the lobster. There are no limbs laterally arranged in pairs, as in the cat and obster; and though it has a pair of jaws, they are no more modified limbs—like the lobster's—than they are modified visceral arches —like the cat's; for such arches are not formed in its development, any more than are a medullary tube and a notochord.

The lobster and cuttle-fish are examples of the most highly-organized sub-kingdoms which make up the Invertebrata, but some species of a sub-kingdom which is in most respects inferior, yet present certain noteworthy approximations to cat-structure. The sub-kingdom referred to is that of the *Tunicata*. Some of these Ascidians are marine animals, with a leathery coat, or "test," shaped somewhat like a bottle with two short necks. Such a creature is alike devoid of anything, either in the shape of an external limb or of an internal skeleton. Its nervous system consists of little more than a ganglion, while (as in a multitude of Invertebrata of different kinds, both male and female sexual glands co-exist in each individual. Such is its adult condition. Yet during its growth it possesses a medullary groove that becomes a dorsal tube developing the nervous centres, which are temporarily in the form of an elongated axis; while beneath it a structure is formed which closely resembles the chorda dorsalis of the cat's embryo. It is only in some Tunicata, however, that this condition temporarily obtains, though in all, the nervous centres are dorsal in position and origin. There are no visceral clefts and arches as in the embryo cat, yet a number of serial openings are formed on each side of the pharynx, which persist throughout life, and through which water is propelled by the lashings of vibratile cilia.

All the creatures yet mentioned resemble the cat, inasmuch as they exhibit either a serial or a bilateral symmetry, or both.

But there may be another form of symmetry (entirely absent in the cat,) namely, a *radial symmetry*, which is exhibited by jelly-fishes, sea-urchins, star-fishes and others.

In various Invertebrate sub-kingdoms, various forms of organic inferiority are found. Some animals grow up in compound aggregations, as do so many of the *Cœlentera*. These last-named animals have a certain interest for the student of Cat embryology. We saw that in the fertilized ovum of the cat, yelk division ended in the formation of two layers—one superficial layer of epiblast, with a hypoblastic layer beneath it. Amongst the Cœlentera we find animals whose whole body, through their whole lives, consists only of two corresponding layers: an external layer, the "ectoderm," and an internal layer, the "endoderm;" the endoderm like the embryonic hypoblast of the cat,) lining the alimentary cavity. These resemblances are not merely fanciful, for the conditions, which exist in a multitude of intermediate forms, show that there is a real affinity of nature between these corresponding parts

of these so widely different animals. Amongst the lowest animals of all—the Hypozoa—we find conditions which remind us of still earlier stages of the cat's existence, and also of fragmentary portions of its adult frame. Amongst those lowly parasites the *Gregorinida*, are animals which consist only of a spheroidal particle of protoplasm enclosed in a cell-wall and containing a nucleus and nucleolus—quite comparable therefore with the cat's ovum. Amongst other lowly creatures called Flagellata, some consist of a small spheroidal particle of protoplasm, with a filamentary prolongation, or tail, by the lashings of which the little creature propels itself along. Such organisms are evidently comparable with the cat's spermatozoa. Yet other lowly organisms amongst the *Rhizopoda* consist of particles of protoplasm which slowly change their shape in an altogether irregular manner, and which quite resemble the white corpuscles of the cat's blood. Such animals are called *Amœbæ*, and it was with reference to them that the motion of these blood-corpuscles was spoken of as "amœboid," or "amœbiform."

But these creatures have a further interest for us. Each Amœba feeds both by imbibing nutritious fluid and by actually engulphing within its substance undissolved nutritious particles, and this process is comparable with what must take place in the nutrition of the protoplasmic particles which form the ultimate parenchyma of the cat's body. Again, each Amœba effects a gaseous interchange with its surrounding medium, gives out carbonic acid and takes in oxygen, and this process is directly comparable with that intimate and internal process of respiration before described as taking place throughout the particles of the cat's parenchyma. Finally, many of these lowly animals have the power of secreting within their unicellular bodies and extruding from them various formations of different kinds, and this process is also comparable with the like actions of the epithelial cells which line the ultimate gland-tubules of the cat, and also with that universal process of minute and ultimate excretion which is carried on by the particles of its ultimate body-parenchyma.

But the whole of the sub-kingdom *Hypozoa* has also an interesting resemblance to the embryonic condition of such an animal as the cat at a period anterior to its differentiation into distinct tissues. For all the Hypozoa consist either of single cells or of more or less simple aggregation of cells, and in no hypozoon are these collected and differentiated into tissues—not even into an epiblast and hypoblast—conditions which appear for the first time in the sub-kingdom, *Spongida*.

§ 9. Inasmuch, then, as the cat is a BACKBONED ANIMAL, it may be said to differ from the whole of the INVERTEBRATA in the following points:—

(1) Its body consists, in the adult as well as in the young condition, of two unequal antero-posteriorly elongated cylinders—one placed dorsally, the other ventrally.

(2) The central part of the nervous system is, throughout life, an elongated structure in the dorsal cylinder.
(3) The two cylinders are, throughout life, separated by an elongated solid structure—the vertebral bodies or (in the fœtus) their cartilaginous or soft representative.
(4) The heart is placed on the ventral side of the thus separated off ventral cylinder.
(5) The anterior end of the alimentary canal bends down away from the nervous centres.
(6) Limbs being present,* they are neither more nor less than four, and have an internal skeleton wrapped round by muscles.
(7) There is a portal circulation.
(8) Jaws being present, they are formed from visceral arches.

Were it not for the existence of a very lowly-organised fish, the *Amphioxus* or lancelet, on the one hand, and of the tunicates above referred to on the other, additional distinctive characters to those just given could be drawn out. For the lancelet has no distinct skull, head, brain, auditory organs, chambered heart, or parts formed from visceral arches, such as those we have made acquaintance with. The cat then, as a backboned animal, of a type superior to the lancelet, differs from all Non-Tunicate Invertebrata, not only in the above enumerated characters, but also in that:

(1) Its body is doubly cylindrical at any time of life;
(2) Its nervous centres are an elongated dorsal axis at any time of life;
(3) It has a vertebral column;
(4) It has a brain enclosed in an anteriorly expanded part of the dorsal cylinder, *i.e.*, in a skull;
(5) It has mandibular and hyoidean arches;
(6) The first sign of the embryo is a medullary groove where the nervous centres take origin;
(7) Visceral clefts and arches are formed.

§ 10. Such being the relations borne by the cat as a backboned animal to all the creatures which form the Invertebrate SUB-KINGDOMS, the next point to examine is its relations to its fellow Vertebrates.

Now the sub-kingdom Vertebrata consists of three PROVINCES and five CLASSES as follows:—

It consists of the province ZYGENCEPHALA,† containing one class only, the class *Mammalia*, which is the class to which all beasts, including of course the cat, belong, and of which man also (zoologically considered) is a member. The province MONOCONDYLA‡ contains two classes: the class *Aves* (birds), and the class *Reptilia*. The latter

* This mode of expression is used because many back-boned animals have no limbs, and we are here considering only such characters in the cat as are common to every back-boned animal.

† A term referring to the median union of the cerebral hemispheres by a corpus callosum.

‡ A term referring to the union of the skull and spine by one occipital condyle only.

class embraces all crocodiles, lizards, serpents, and tortoises, with extinct forms more or less allied to these. The province BRANCHIATA* is the third and last. It consists of two classes: the class *Batrachia*—*i.e.*, the class of frogs, toads, efts, and their allies—and the class *Pisces*, which includes all fishes.

Our present task, then, is to see what is implied in saying that the cat is a "beast" or a "mammal." To see this we must know its relations, simply as a mammal, to the other forms of vertebrate life, *i.e.*, to the groups Pisces, Batrachia, Branchiata, Reptilia, Aves, and Monocondyla, and to all the non-mammalian vertebrates taken together.

If, to help us in our comparisons, we examine any ordinary fish, such as the cod (*Gadus*), we see in it an animal with a large, neckless head and a long and powerful tail, with a membranous production from the back (a *dorsal fin*), one beneath the tail (an *anal* fin), and two pairs of fins placed laterally, ventrally and far forwards, and termed respectively the *pectoral* and *ventral* fins. The body of the fish is clothed with scales, and exhibits an undulating mark running from before backwards (from head to tail) on each side, called the *lateral line*. The tail ends in a membranous, vertical expansion, or *caudal* fin, which is supported (as are all the other fins) by many delicate but firm fibres within its substance, called *fin-rays*. The nostrils do not open into the mouth posteriorly, but each has two openings on the exterior of the snout. The orbits do not communicate with the nares by any lachrymal tube, nor the ears with the mouth by any Eustachian tube, but there is a large aperture on each side behind the head, which leads into a chamber wherein are a number of membranous plates, or "gills," attached to the outside of a series of arches between which are clefts leading into the alimentary canal just behind the mouth. These gills are breathing organs, adapted to aid the needful respiratory gaseous exchange between the blood within them and the atmospheric air which is dissolved in the water the animal inhabits. There is a perfectly-closed air-bladder just beneath the vertebral column, but there are no lungs and no pulmonary arteries. The aorta divides—as in the embryo cat—into a series of arches which ascend the sides of the pharynx to reach the dorsal aorta, but each artery is, on its way upwards, broken up into a network of minute capillary vessels within the membranes or leaflets of the gills. Thus the blood leaves the heart in an impure or venous condition, and, having gone thence to the aquatic respiratory organs—or gills—it does not return directly to the heart, but passes up in an arterial condition to the dorsal aorta. Consequently neither a second auricle nor a second ventricle is required, and neither exists—the heart consisting, as in the embryo cat, only of a single auricle and ventricle, the venous blood passing into the former from a "sinus venosus," and being given

* A term referring to the all but universal presence of gills (at one time of life if not permanently) in all Batrachians and Fishes.

r the latter into a "bulbus aortæ," whence the lateral aortic s take their origin. Other transitory conditions of the cat's ronic circulation are found persistent in the cod. Thus the is brought back to the heart by large anterior and posterior ıal veins which unite on each side in a "ductus Cuvieri," which into the sinus venosus, and no large iliac arteries, or great ior and posterior venæ cavæ are ever developed. Similarly in levelopment of the cod, no umbilical veins or arteries ever r, for no allantois (and indeed no amnion) is ever formed; but mphalo-meseraic arteries and veins are the only ones employed urishing the embryo. But the nature of the arches which rt the gills needs explanation.

e have seen how, in the cat, the hard parts of the successive al arches of the embryo respectively become the mandible, the of bones forming the anterior cornu of the os hyoides, and also sterior cornu or thyro-hyal.* In the cod, similar arches also ıe (successively from before backwards), the mandible and the of bones answering to those of the cat's anterior hyoidean . But the visceral arches more posteriorly placed, become successive arches which (because they support the gills) are "branchial"—one branchial arch being formed from each more posteriorly-situated visceral arch. All the gill-arches of side answer, in fact, to one of the cat's thyro-hyals, as we see more distinctly in considering Batrachians.

e two pairs of lateral fins before noticed—the *pectoral* and *l* fins—answer to the pectoral and pelvic pairs of limbs of the ut their internal skeleton is not divisible into arm, carpus, and ; or leg, tarsus and digits—that is to say, they have not what ay call the "*typical differentiation*." † The muscles of the are few in number and simple in arrangement. The ventral re attached to two bones which answer to the cat's pelvis, but ıre so far from forming a "limb-girdle" that they do not even o reach the axial skeleton. The "shoulder-girdle," however, l developed, and, though there is no sternum, it is complete in iddle line below, while above it is continued on by bones till it against the skull.

lower jaw consists of more than one bone on each side, and is ed to the skull by the intervention of a complex, bony, and ginous structure, which may be shortly spoken of as a *sorium*. Into its composition parts enter which correspond auditory ossicles of the cat. On the base of the skull is a long bone called the *parasphenoid* (which is not represented in t's skull, save by membrane on the basis cranii), but there is no)henoid and the periotic bones (*i.e.*, the pro, epi and opisthotics) ı as distinct, permanently, as they temporarily do in the o cat. They do not, therefore, coalesce to form a "petrous

* *ante*, p. 339

† called because it exists in all vertebrates which have limbs and which are not fishes.

The brain has very small cerebral hemispheres unconnected by any corpus callosum, and the optic lobes are relatively very large, thus agreeing with the brain of the embryonic cat. There are no hypoglossal nerves, and the olfactory nerves do not traverse any cribriform plate, nor has the ear any tympanic membrane, spiral cochlea or fenestra ovalis. There are no Fallopian tubes, and the ovaries in the female are (as well as the testes in the male) directly continuous with ducts which lead to the exterior. There is no cloaca and there is no penis, but the anal, urinary, and sexual apertures all open on the surface of the body, the anal opening being in front and the urinary opening the most posteriorly situated. No temporary urinary organs are developed to be replaced by true kidneys, but the primitive urinary organs persist. The blood is cold, and its red corpuscles are nucleated. There being no lungs and no trachea, there is of course no larynx. Similarly there is no diaphragm, such as we have met with in the cat.

Fishes, generally, agree with the cod in the above-mentioned characters, but some exceptions should be noted. The lowly organization of the lancelet has been already referred to. Amongst the highest fishes, such as the sharks and rays, the skeleton is cartilaginous; there is a cloaca, and there are Fallopian tubes. In the very exceptional mud-fish (*Lepidosiren*) the heart has two auricles, the nostrils open posteriorly within the front of the mouth, and there are lungs and a pulmonic circulation.

§ 11. The cat then, inasmuch as it is a MAMMAL, may be said differ from the class of FISHES in the following points:—

(1) It has a skeleton, the appendicular parts of which have the typical differentiation.
(2) The hyoid is a structure with simple thyro-hyals, which are not in the form of successive arches.
(3) The skull has a large basi-sphenoid, without any parasphenoid.
(4) It has a petrous bone.
(5) Its mandible consists of two bones only—one on each side.
(6) The mandible directly articulates with the skull, and there is no suspensorium.
(7) The auditory ossicles are minute, and take no share in suspending the mandibles to the skull.
(8) There are cervical vertebræ.
(9) Its ribs join a sternum.
(10) Having pelvic limbs,* its pelvis is united dorsally to a sacrum.
(11) The body is furnished with hair.
(12) The muscles of its limbs are complex.†

* This expression is adopted because in some mammals which have no pelvic limbs there is no junction of pelvis and sacrum.

† Even in mammals such as the porpoise, in which the limbs are more pelvic, the muscles are very different from those of the cod.

(13) Its cerebral hemispheres are large, and united by a corpus callosum.
(14) There are small corpora quadrigemina instead of large optic lobes.
(15) There are hypoglossal nerves which perforate the exoccipitals.
(16) The olfactory nerves being present,* traverse a cribriform plate.
(17) The ear has a tympanic membrane and an Eustachian tube.
(18) The posterior nares open far back within the mouth.†
(19) There are no gills at any time of life.
(20) Respiration after birth, is pulmonary only.
(21) The heart consists of two auricles and two ventricles.
(22) All the blood of the body traverses the lungs.
(23) There is but one aortic arch.
(24) There is a large anterior vena cava and a large posterior vena cava.
(25) There is a larynx.
(26) The hinder end of the alimentary canal does not terminate anteriorly to the urinary outlet.
(27) There is a complete diaphragm aiding respiration.
(28) There are no fin rays.
(29) The red blood-corpuscles are not nucleated, and the blood is warm.
(30) There are cervical vertebræ.
(31) In development an amnion is formed.
(32) Cardinal veins, at first important, afterwards become subordinate to the venæ cavæ.
(33) Kidneys replace transitory Wolffian bodies.
(34) There is an allantoic placenta.‡
(35) There is a fenestra ovalis.

§ 12. We come now to the class BATRACHIA, which contains, besides the frogs, toads, and commoner efts, certain noteworthy eft-like atures, such as the gigantic salamander of Japan and China, the *nopoma*, *Amphiuma*, *Menobranchus* and *Siren* of the United States, *Axolotl* of Mexico, and the *Proteus* of the dark subterranean erns of Carniola and Istria. Besides these animals, the class also tains certain limbless creatures which look like something between kes and earthworms. They have long, slender bodies, marked by ny transverse wrinkles, and are called *Ophiomorpha*. Creatures ich lived during the deposition of the carboniferous strata, and which known as *Labyrinthodonta*, are also included amongst Batrachians. e common frog (*Rana temporaria*) may be taken as a type of this ss. This animal has two pairs of well but unequally developed

* In a few mammals they are absent.

† That they open into the mouth at would serve to distinguish the cat's s from all fishes save such as the *idosiren*.

‡ In certain sharks a placenta is formed, but by the intervention of the umbilical vesicle. It is not therefore an allantoic placenta.

limbs, each of which ends in four or five digits, and has the typical differentiation. Though without a neck externally visible, it may be reckoned as having one cervical vertebra. Its body is not only devoid of hair, but also of scales, and is perfectly naked and more or less moist—its surface helping importantly in the respiratory process. The adult has no fins, but in the young, or tadpole condition, fins are present, but are always devoid of fin rays. Neither is there any lateral line. The nostrils open within the mouth, and the tympanic cavity communicates with the throat by a wide and short Eustachian canal. In the adult, there are no gills, but there are lungs with pulmonary arteries and veins and two auricles. Nevertheless not all the blood goes through the lungs at each circuit; and there are several aortic arches. In the young there is but one auricle, and there are gills and an arrangement of vessels substantially as in the cod. Similarly in the young there are gill arches behind the hyoidean cornua, which latter answer to the anterior hyoidean cornua of the cat. In the course of development, however, these hinder gill arches shrivel into what evidently represents the thyro-hyals of the cat. The blood has its red corpuscles nucleated, and the cardinal veins of the young become subordinate to the subsequently developed venæ cavæ. The pelvic limbs are attached to a pelvic girdle which joins a sacrum, but no ribs articulate with the sternum. The muscles of the limbs are numerous and complex. The skull has a large parasphenoid, but no basi-sphenoid. The periotic bones coalesce. The cranium joins the spine by two occipital condyles, but the basi-occipital is rudimentary. The mandible consists of more than two bones, and it is suspended to the skull by a complex suspensorium, including parts representing the auditory ossicles. The same may be said of its brain as has been said of the cod's. The olfactory nerves traverse no cribriform plate, but there is a well-developed tympanum, though there is no spiral cochlea. The alimentary canal and renal and sexual ducts open into a common cloaca, and the primitive urinary organs persist. Respiration, though serial, is not effected by a diaphragm, but the lungs open into the alimentary canal by a short tube, at the anterior end of which is a simple larynx.

§ **13**. Bearing in mind the conditions presented by the other forms of the class Batrachia, we may say that the cat, as a MAMMAL, differs from all BATRACHIANS, as follows:—

(1) Its skull has a large parasphenoid, but no presphenoid.
(2) Its mandible consists of two bones only, one on each side.
(3) Its mandible directly articulates with the skull, and there is no suspensorium.
(4) Its auditory ossicles are minute, and take no share in suspending the mandible of the skull.
(5) Its ribs join a sternum.
(6) Its body is furnished with hair.
(7) Its cerebral hemispheres are large and united by a corpus callosum.

(8) It has small corpora quadrigemina instead of large optic lobes.
(9) Olfactory nerves being present, they traverse a cribriform plate.
(10) The posterior nares open far back within the mouth.
(11) There are no gills at any time of life.*
(12) Respiration is pulmonary only from birth.
(13) Its heart is furnished with two ventricles.
(14) All the blood of its body traverses the lungs.
(15) It has but one aortic arch.
(16) There is a complete diaphragm aiding respiration.
(17) Its red blood-corpuscles are not nucleated, and its blood is warm.
(18) There are several cervical vertebræ.
(19) In development an amnion is formed.
(20) Kidneys replace transitory Wolffian bodies.

All these characters serve to distinguish the Cat's class from that of Fishes, as well as from Batrachians, and therefore they will also serve to distinguish the cat, in so far as it is a mammal, from the whole province BRANCHIATA.

§ 14. From amongst the creatures included in the class REPTILIA (the lower of the two classes which make up the province *Monocondyla*) we may select, as a type, the common lizard (*Lacerta agilis*). In it we find a little long-tailed quadruped, the body of which is clothed with horny epidermal scales. The thoracic and abdominal portions of its body-cavity are not divided by a diaphragm, for it—unlike that of the cat—forms no complete partition. The ribs are connected with a sternum. The skull has but one occipital condyle. The mandible consists of more than one bone on each side, but is connected with the skull by one bone only—the *os quadratum*. This bone answers to the proximal part of the cat's malleus, while the part of the mandible which articulates with it answers (as it does also in the Branchiata) to the distal part of the malleus. There is no cribriform plate. The periotic bones unite with adjacent skull bones before uniting with each other, so that they do not form a "petrous bone." The limbs have the typical differentiation, and the pelvis joins the sacrum. But the joint of the hind foot with the leg, is not situated between the tarsus, as a whole, and the tibia, as is the case in the cat. It is situated in *the middle of the tarsus*, the proximal part of which is firmly bound to the tibia by fibrous tissue, while the distal part of it is similarly bound to the metatarsus. The phalanges of the digits are more numerous than in the cat, and differ in number in different digits. There is no corpus callosum, but there are a pair of large optic lobes. The lungs are freely suspended in the thoracic cavity, but the bronchi do not branch within them dichotomously. The two ventricles of the heart are

* This and the next character do not apply in every case, as the young of the pipa toad, and of one or two other kinds, seem never to develop gills.

but incompletely divided, and the posterior nares open far forwards within the mouth. There are Fallopian tubes, and in development both an amnion and allantois are formed, but no placenta—the allantois being itself directly respiratory. There are never any gills.

Some lizards and almost all serpents are limbless, but the crocodiles and alligators differ from the other reptiles in having two distinct ventricles, with nares prolonged to quite the posterior end of the palate. Nevertheless, even in crocodiles, there is more than one aortic arch, and these arches so communicate that a mixture of venous and arterial blood takes place in them.

§ **15.** We may then say that the cat, as a MAMMAL, differs from the whole class REPTILIA in the following characters:—

(1) There is a petrous bone, and a mandible formed of two bones only, each directly suspended from the squamosal.
(2) The auditory ossicles are minute, and take no part in suspending the mandible.
(3) There are two occipital condyles.
(4) The skin is furnished with hair.
(5) There is a corpus callosum, and the corpora quadrigemina are small.
(6) There is a cribriform plate.
(7) All the blood passes through the lungs at each circuit.
(8) There is no communication between the arterial and venous vessels outside the heart, save the capillaries.
(9) There is but one aortic arch.
(10) There is a complete diaphragmatic partition.
(11) There is no intertarsal joint, the tarsus moving as one whole upon the tibia.
(12) The red blood corpuscles are not nucleated, and the blood is warm.

With the exception of the crocodiles and alligators, we may say that the cat also differs from all reptiles:—

(13) In that it has two distinct ventricles, and
(14) In that the posterior nares open far back within the mouth.

§ **16.** Turning now to the class AVES, whatever bird we may select as our type, will exhibit to us structural peculiarities well deserving attention. The rook (*Corvus*) will be a good example to contrast with the cat and the cat's class. Its different external aspect (as compared with the cat) depends upon the following conditions:—The rook's posture, on the ground, is nearly upright, its body being supported on the legs only, the pectoral limbs being modified into wings. The facial part of the head is produced into a long, conical, pointed beak. The region of the chest is rounded and prominent. The whole frame (except the beak and legs) is clothed with feathers, and it is to them that the appearance of a long tail is due, for only a stumpy tail-structure is visible when they are removed. The feathers are very different in different parts of the body, much the longest being attached to the tail and arm, and

especially to the distal segment of the arm, which corresponds to the fore-paw of the cat. The lower parts of the legs are clothed with horny scales.

In internal structure, the main characters agree with those of the cat, but there are a multitude of differences. The more significant of these are as follows:—The thoracic and abdominal cavities are not quite separate, the diaphragm forming only an incomplete partition.

The cervical vertebræ are thirteen and the dorsal eight, and behind these no less than ten, at the least, are fused with the pelvis into a great solid sacral mass which includes even the last two dorsals. The caudal vertebræ are few and end in a bone, shaped somewhat like a ploughshare, called the zygostyle.

The ribs which are connected with the sternum are connected with it, not by the intervention of costal cartilages, but by long narrow bones (sternal ribs) instead.

The sternum consists mainly of a great flattened quadrangular sheet of bone, from the middle of the ventral surface of which a long and strong *keel* projects, supporting a mass of flesh which lies on each side of it, and which is related to the power of flight.

The skull has but one occipital condyle, and the front apertures of the nares are placed some distance back from the front end of the skull—one on each side of the bony beak. No zygoma passes back from the hinder margin of the orbit, but a needle-like bone bounds the orbit externally below, passing backwards from the beak to abut against a movable complexly shaped bone—the *os quadratum*. Inside the skull there is no cribriform plate, but only a foramen for the nerves of smell, while the bony palate shows some large openings, two of these being the posterior nares. The periotic bones unite with other cranial elements before uniting together.

The lower jaw, toothless like the upper, is made up of several bones on each side. It does not join the squamosal, but fits, by an irregularly shaped hollow cup, to the lower part of the os quadratum.

The shoulder-girdle is complete. Instead of each blade-bone having only a small coracoid process, there is, as in the lizard, a large and distinct coracoid-bone, which passes down from the slender blade-bone to abut against the breast-bone, and the arch is further complete by the clavicles which, instead of being two separate slender little bones embedded in the flesh alone, here form the merrythought or *furculum*, which above abuts against the coracoids and scapulæ, and below is firmly fixed to the sternum.

The anterior extremity of the pectoral limb is greatly reduced, exhibiting only rudiments * of the parts we saw in the cat's fore-paw.

The pelvic girdle is at once more complex and less complete than

* There are two carpal bones; three metacarpals united in one mass (though two are separate save at their ends), and three digits with one or two phalanges.

in the cat. As has been said, it unites dorsally with many vertebræ in one large mass, while ventrally it is widely open. The acetabulum is perforated.

The *fibula* is but a needle of bone fused below with the *tibia*, but the most surprising thing is, the apparent absence of a *tarsus* altogether.

Directly below the tibia there is only one long bone, which represents three metatarsals united in one and supporting three digits, while at the lower end of its inner side is a small separate metatarsal bone for the fourth digit. In fact, in the rook, the tarsus has partly united with the tibia, and partly with the metatarsus, so that the joint is placed not between the tibia and the tarsus, but in the middle of the tarsus itself, which has become blended with adjacent parts—the proximal part of the tarsus anchylosing with the tibia, while its distal part anchyloses with the tarsus.

As in the cat, so here, there are only four digits, but in the rook it is the representative of the outermost or little digit, not of the hallux, which is absent. Counting from within outwards, the numbers of the phalanges are two, three, four and five, a different number for every digit.

The spinal marrow has the lower parts of its *canalis centralis* expanded, while at the same time in the brain the ventricles are small and there is no fifth ventricle.

The smaller hemispheres are also not connected by any *corpus callosum*, and instead of corpora quadrigemina there are two lobes called *optic*, placed one on each side in a lateral and depressed position. The two Eustachian tubes open into the alimentary canal by a single aperture.

The great artery, the aorta, sends out only one branch, which arches over the right bronchus. The right auriculo-ventricular valve is muscular and not merely membranous as in the cat.

The lungs are not freely suspended in the thorax, but are fixed to the back of its cavity, and the bronchi do not divide dichotomously within the lungs. Moreover, they communicate with air-sacs, which not only extend within the body but even enter certain of the bones, which are thus themselves filled with air. Thus the circulating and respiratory structures are such as to give to their functions an even greater perfection than in the cat. This perfection is needed for the almost constant activity of the bird, and the enormous muscular power it has to exert in flying. Where the trachea divides into the two bronchi there is a special arrangement of parts called the *syrinx*, or "lower larynx," the upper larynx (which corresponds with the larynx of the cat) being much smaller.

The ureters do not open into the bladder, but into a chamber or reservoir (the *cloaca*), into which the bladder also opens, while the cloaca itself opens on the surface of the body. It is also into this cloaca that the posterior end of the alimentary tube opens, and not on the surface of the body. Into it also open the ducts from the testes in the male, and the (here single) Fallopian tube of the

female. Both testes and ovaries are enclosed in the abdominal cavity, and in the rook there is no urethra or prostate or Cowper's glands, and no penis or clitoris, vagina or uterus, or any mammary glands. No placenta of any kind is formed, but the allantois is directly respiratory. It lines the egg shell, which is porous enough to admit of the respiratory gaseous interchange taking place through it.

In almost all the differences from the cat here enumerated, all birds agree with the rook, whatever may be their habit of life or the general external influences to which they are exposed.

Thus the ostrich and apteryx cannot fly, and yet their pectoral limb is formed on the type* of that of the crow, as also is the subaqueous paddle of the penguin, a bird as incapable of flight as the ostrich.

§ **17.** The cat is then, as a MAMMAL, distinguished from BIRDS in that:

(1) Its skull has a "petrous bone," and a mandible formed of two pieces only and suspended directly from the squamosal.
(2) Its auditory ossicles are minute and take no part in suspending the mandible.
(3) There are two occipital condyles.
(4) Its skin is furnished with hair.
(5) Its cerebrum is large, with a corpus callosum, and its corpora quadrigemina are small.
(6) Olfactory nerves being present, there is a cribriform plate.
(7) Its ear has a complex, spiral cochlea.
(8) Its solitary aortic arch, arches over the left bronchus.
(9) No air-cells communicate with the lungs.
(10) It has no syrinx, but a large and complex larynx.
(11) Its lungs are freely suspended in the thoracic cavity.
(12) It has a complete diaphragm.
(13) Its posterior nares open far back within the mouth.
(14) The ulna is larger than the radius.
(15) The skeleton of the extremities is arranged on a different type.
(16) The pelvis extends less forwards.
(17) The ankle-joint is not an intertarsal one.
(18) The proximal and distal parts of the tarsus do not anchylose with the tibia and metatarsus respectively.
(19) The caudal vertebræ do not end in a "ploughshare† bone."
(20) The red-blood corpuscles are not nucleated.
(21) The right auriculo-ventricular valve is membranous only and not muscular.
(22) It has no feathers.
(23) The corpora quadrigemina are not laterally depressed.
(24) The Eustachian tubes open separately within the alimentary canal.

* In these birds the breast-bone though wide is keelless.

† Neither do they in the extinct mesozoic bird—the Archeopteryx.

(25) No digit of the pelvic limb has more than three phalanges.*

The first eight of the foregoing characters, together with the 12th, 17th, and 20th, serve to distinguish the cat, as a MAMMAL, from the whole of the province MONOCONDYLA. It is also distinguished from all BACK-BONED ANIMALS WHICH ARE NOT MAMMALS, in the following points:

(1) The mandible consists only of one bone on each side, and directly articulates with the squamosal.
(2) The malleus and incus are only small auditory ossicles.
(3) The periotic bones anchylose together to form a petrous bone before anchylosing with parts of the occipital.
(4) There are two occipital condyles co-existing with a distinct basisphenoid.
(5) There is a cribriform plate unless olfactory nerves are absent.
(6) There is but one aortic arch, which arches over the left bronchus.
(7) Two auricles and two ventricles co-exist with a membranous right auriculo-ventricular valve, and a single aortic arch.
(8) There is more or less hair.
(9) There is a corpus callosum and fifth ventricle.
(10) The red-blood corpuscles are not nucleated.
(11) There is a complete diaphragm, which acts as the main respiratory organ.
(12) The male has a penis traversed by the urethra.
(13) The female is provided with mammary glands.

Such then is the cat's place in nature, so far considered. The cat is a beast, or mammalian back-boned animal, because it has the anatomical characters above enumerated, and the varying degrees of its divergence from the other provinces and classes which go to make up the sub-kingdom Vertebrata, are to be estimated according to the variations of structural conditions which have been indicated in the lists of characters above given. It remains to see the rank and position which the cat may claim amongst its fellow mammals.

§ **18**. Besides the creature to the study of which this book is devoted, all the animals most familiar to us and most generally valuable to us—as our dogs and our domestic cattle—are members of the class Mammalia. The name "beasts" is in more or less general use to denote the various brute animals which belong to the class; but since man himself—the most individually numerous of all the large animals—is, structurally considered, also a member of it, the name "Mammals" will be henceforth always exclusively here employed to denote the creatures which compose it.

Hitherto we have been occupied but with sub-kingdoms, provinces, and classes; the characters of subordinate groups of the Invertebrate sub-kingdoms having no bearing upon the question to the cat's place in nature. Now, however, such subordina-

* This can only be affirmed of the pelvic limb, because the pectoral limb of some aquatic mammals (Cetacea) has digits with more than three phalanges.

roups, as they exist in the class Mammalia, must be more r less considered; for the cat belongs to a mammalian genus which comprises the majority of the forms reviewed in the twelfth hapter of this work. The whole of these forms—all the lions, igers, leopards, jaguars, pumas, ocelots, lynxes, cheetahs, and other living and extinct cats—form together a group which has the zoological rank of a "family," and it is a family of an "order" divisible into "sub-orders," while the order itself is one of various others which go to make one of the three very unequal "sub-classes" which together make up the whole class Mammalia. The class Mammalia has been now compared with all the other classes of back-boned animals, and the vertebrate sub-kingdom with all other sub-kingdoms of animals. It remains to compare the cat's *sub-class* with the other mammalian sub-classes; the cat's *order* with the other orders of its sub-class; the cat's *sub-order* with the other sub-orders into which its order is divisible, and the cat's *family* with the other families which, together with that family itself, make up the sub-order within which the cat is included. This done, we have but to consider the results arrived at in the twelfth chapter as to genera into which the cat's family is divisible, in order to exhaust our present inquiry by attaining a final and satisfactory answer to the question "What is the cat's place in nature?" and to understand the cat's taxonomy.

Closely allied to the domestic cattle—our sheep and oxen—are all bisons, buffaloes, goats, antelopes, deer, giraffes, chevrotains,* llamas, and camels. Less closely allied, but still allied, are all peccaries and swine, and the hippopotamus. With these, also, may be associated the rhinoceros and tapirs, and lastly all asses, quaggas, zebras, and horses. All these creatures together constitute one order of mammals, the order UNGULATA, into which the little hyrax, the "coney" of the English Bible, may or may not be admitted, according to the view of classification adopted.

Somewhat allied to ungulates, but distinct from them, are the elephants, which form the order PROBOSCIDEA, an order which once—with its various species of elephant, large and small, its Mastodon and Dinotheria—was rich in species and individuals, and was widely distributed over the world's surface.

Somewhat related to them again is the numerically very small order SIRENIA: an order now containing only the Manatee and Dugong, although another genus, *Rhytina*, still existed at no distant period.†

Other marine creatures, really very different in nature from the Sirenia, were long classed with them. These are the many kinds of whalebone-whales, porpoises, sperm-whales, and dolphins, which together make up the order CETACEA. Yet other marine creatures, of less decidedly and exclusively aquatic habits, are the seals and sea-

* Very small animals, commonly called the error musk-deer.

† It was exterminated in the year 1768.

lions (or sea-bears), which constitute the order PINNIPEDIA. All kinds of apes, together with man, and certain animals called "Lemuroids," form another mammalian order—one to which Linnæus gave the name PRIMATES. Lemurs are animals with fox-like snouts, but with paws like those of apes, which inhabit the geologically remarkable island of Madagascar. "Lemuroids" are lemurs and creatures like lemurs, and such are found either in Madagascar, or more or less in the vicinity of the Indian Ocean, though a few reach western Africa.

The only beasts which truly fly are bats, which form an order by themselves. It is well named CHEIROPTERA, since their wings are enormously spread-out hands with webbed fingers. When Australia was discovered, very many new and strange mammals were there found; differing amongst themselves greatly in external appearance, mode of life, food, and size. Large kangaroos browsed over the plains, taking the place elsewhere occupied by browsing ungulates. Many phalangers climbed the forest trees, with feet the great toes of which were prehensile, acting like "hind-thumbs," as in the feet of apes. Certain small quadrupeds with molar teeth bristling with sharp points — the bandicoots — fed on insects, while the wombat, a squat-shaped sluggish animal, was specially qualified for nibbling and grinding vegetable food by two large incisors above and below, followed (after a wide diastema) by flat-surfaced molars. Some Australian mammals were enabled to take prolonged jumps by means of lateral skin extensions which procured for them the name of "flying opossums" (*Petaurus*, &c.). Other mammals were more or less fierce beasts of prey, with teeth remotely like those of the cat, and with blood-thirsty habits. Such were the native-cats or Dasyures, and the Thylacine or Tasmanian wolf. All these various mammals, however different in form, together constitute but a single order, MARSUPIALIA, an order into which the insect-eating and flesh-eating opossums of America must also be admitted. Two other Australian forms justly excited wonder when discovered. One of these was the platypus or *Ornithorhynchus* (with a squat, hairy, body, short limbs, and a duck's bill); the other was the *Echidna*—an animal covered with spines, and with a slender snout devoid of teeth, a long tongue, and strong nails suited to its ant-eating habits. These two forms by themselves constitute the order MONOTREMATA.

In South America other edentulous, strong-clawed ant-eaters are found, which, with the South African Aard-vark (*Orycteropus*), the scaly pangolins (*Manis*), the sloths and armadillos, with the huge extinct *Megatherium* and *Mylodon*, together make up an order called EDENTATA. Insect-eating beasts (mostly small, and having among them the absolutely smallest mammal), such as the hedgehog, the Asiatic *Gymnura*, the moles, shrews, elephant-shrews, water-shrews, tupaias, tanrec (*Centetes*), *Solenodon*, *Potomogale*, the golden mole, &c., are all united in one ordinal group, which bears the name of INSECTIVORA. Another very large ordinal group has teeth like those of the wombat. This is the order RODENTIA, which contains a

mice, squirrels, guinea-pigs, porcupines, beavers, jerboas, rat-
s, and rabbits and hares. Some rodents are, like the flying
sums, fitted to flit through the air in long jumps, by means of
wide extensibility of the skin of their flanks, which, when
ched out, acts as a parachute—such are the so-called "flying-
rrels" and the genus *Anomalurus*.

astly we have the order to which all the kinds of cats belong,
ther with all pole-cats, civet-cats, hyænas, bears, weasels, dogs,
es, and foxes—the order of flesh-eating mammals *par excellence*,
ARNIVORA.

hese various orders of the class Mammalia are grouped together
three sub-classes as follows :—

he order *Monotremata* is an order so exceedingly different from
he others that there can be no doubt (in spite of the few species
ntains) of its forming a sub-class by itself. It forms the sub-
ORNITHODELPHIA.

he order *Marsupialia* differs much less from the great bulk of
mals than does the order *Monotremata*, nevertheless it also is
oned as forming a second sub class by itself. It forms a sub-
much more numerous than the sub-class *Ornithodelphia*, yet it
ains but very few species when compared with the number of
ies contained in the third sub-class. The second or Marsupial
class bears the name DIDELPHIA. All the rest of the mammalia—
is to say the whole of the orders *Ungulata*, *Proboscidea*, *Sirenia*,
cea, *Pinnipedia*, *Primates*, *Cheiroptera*, *Edentata*, *Insectivora*,
entia, and *Carnivora*, together make up the third and last
mmalian sub-class, that containing the placental mammals—the
class MONODELPHIA.

19. Now the cat, as a monodelphous mammal, of course shares
characters which distinguish that SUB-CLASS from both the others.
have then first to see how the cat thus differs from the
ithodelphia.

he Ornithorhynchus and Echidna agree together in having an
edingly rudimentary corpus callosum, a condition perhaps more
ss compensated for by the very large size of the anterior com-
ure. In the internal ear, the cochlea instead of being spirally
d, as we saw it to be in the cat, is but slightly twisted. The
ebræ are not ossified by the intervention of epiphyses, and the
lder-girdle is of remarkable complexity. Instead of mere
coid processes, such as we saw in the cat, there are large
coid bones (as in birds) with epicoracoid bones, and an inter-
icle—as in many lizards. The acetabula are also perforated (as
irds) and the fibula sends up a large olecranon-like process,
lering its serial homology with the ulna strikingly evident.
internal tendon of the external oblique muscle of the abdomen
ssified, resulting in the development of two large bones, called
arsupial," which are attached to the front margin of the pelvis.
mouth is either edentulous, or if, as in the Ornithorhynchus,
re are teeth, then these are not calcareous but of a horny

texture. Posteriorly the alimentary canal opens into a cloaca (as in the Monocondyla) which also receives the terminations of the ureters and generative ducts. Thus the ureters do not open into the bladder, although a urinary bladder is fully formed. The penis is perforated by a urethra, but this does not transmit the renal secretion, as it is proximally discontinuous with the cystic urethra, and serves but for the testicular product. There are two uteri, which open side by side into the cloaca, so that there is no vagina any more than in birds—from which circumstance the name of the sub-class is derived. The mammary glands pour out the milk from numerous apertures on the surface of the skin, but these are not aggregated into a distinct prominence or nipple. No allantoic placenta is developed. Thus the cat, as a MONODELPHOUS MAMMAL, differs from the lowest mammalian sub-class, the ORNITHODELPHIA, by the following characters:—

(1) There is (in the female) a vagina.
(2) There is no cloaca.
(3) The cystic and spongy portions of the urethra are continuous, and it transmits the urine.
(4) The ureters open into the bladder.
(5) The mammary glands have teats.
(6) The vertebræ ossify by terminal epiphyses.
(7) Development is effected by the help of an allantoic placenta.
(8) The cerebrum has a large corpus callosum and a small anterior commissure.
(9) The ear has a complex, spirally coiled cochlea.
(10) The coracoids are but small processes.
(11) There are no epicoracoids or interclavicle.
(12) The acetabula are imperforate.
(13) There are no marsupial bones.
(14) The fibula has no olecranon-like process.
(15) There being teeth * they are calcareous.

The animals of the order Marsupialia are all much more like the cat in structure than are the Monotremes. Nevertheless they present such important divergences from the structure of monodelphous mammals, that the whale or bat may both be considered (they being both monodelphous mammals) to be much more fundamentally like the cat than is that opossum which has (on account of its superficial resemblance to our subject) been called the "native-cat."

In all the marsupials the vagina is double—whence the name of their sub-class, *Didelphia*. Their process of development takes place in such wise that the young are brought forth in an extremely imperfect condition. They are, therefore, in the great majority of marsupials, sheltered for a time within a "pouch," (consisting of a fold of the skin of the belly) within which are the nipples. The young are not developed by means of an allantoic placenta, and when born, are so feeble and imperfect that they are unable to suck.

* Some Monodelphous mammals, as we have seen, have no teeth at all.

account the milk is injected by the mother into the young
e it hangs attached by its mouth to the nipple. The injecting
n is effected by the cremaster muscle, which embraces the
mary glands of the females and the testes of the males. The
s hang in a scrotum; but this receptacle is placed in front of
penis instead of, as in the cat, behind it. All marsupials have
upial bones except the Thylacine, which has them represented
rge marsupial cartilages. The internal carotid artery enters
ranium through a foramen in the sphenoid bone. The mandible
its "angle" inflected. The palate has commonly certain
ures due to defect of ossification. The corpus callosum is very
l, and the anterior commissure is large. In such marsupial
s as are carnivorous, the molar teeth are not differentiated into
olars, sectorials, and tubercular teeth—as in the cat and other
ntal carnivora—and there are never six incisors above and six
v. Thus the cat, as a MONODELPHOUS MAMMAL, differs from
IDELPHIA in that:

1) The vagina is single.
2) The young are brought forth in a well-developed condition.
3) There is no "pouch" and the young can suck as soon as born.
4) There are never marsupial bones or large* marsupial cartilages.
5) The mammæ are not embraced by the cremaster.
6) The scrotum being present† is behind the penis.
7) The internal carotid does not perforate the sphenoid.
8) The corpus callosum is large and the anterior commissure small.
9) The angle of the mandible is not inflected.‡
0) There are six incisors in both the upper and lower jaw.
1) Reproduction takes place by the aid of an allantoic placenta.

20. Such being the characters which respectively distinguish
at as a monodelphous mammal from both the mammalian
lasses which are not monodelphous, we have next to compare
DER with the OTHER ORDERS of its own sub-class Monodelphia.
order, *Carnivora*, containing the creatures we have already
it to contain, is easily distinguishable from the two orders
ia and *Cetacea*, because in both the latter the pelvic limbs are
ly wanting, or only represented by rudiments not externally
e.

e Carnivora are distinguished from all animals of the order
tata by possessing median upper incisors, with unequivocal canines
ith molars provided with cutting edges or tubercular prominences
th. From the anteaters they differ in that they are furnished with
; from the pangolins, in that they are not clothed with horny
apping scales; from the armadillos, in that their skin does not
op calcareous plates; from the Orycteropus, in that each tooth

the dog there are very small mar-
cartilages.
ot all monodelphous mammals have a scrotum.

‡ It is so however in the monodelphous mammal—the Tanrec (*Centetes*).

has not a number of small, parallel pulp cavities; and from the sloths, in that their digits are not so closely bound together by skin up to the roots of such enormous curved claws as to reduce the paws to mere hooks by which the body may be suspended.

From the *Cheiroptera* all members of the cat's order differ in not having the fingers enormously produced and webbed so as to form a pair of true wings, enabling their possessor really to fly and not merely to flit like a so-called flying-squirrel or flying opossum.

The Carnivora differ from the *Proboscidea* in not possessing a long trunk or proboscis, and in not having large pendent ears, huge incisor teeth, and an enormous cæcum. Also in having less convoluted cerebral hemispheres, two canines above and below, and digits which are furnished with claws, *i.e.* are unguiculate.

The *Primates* are all distinguishable from the Carnivora in that they are monodelphous mammals with either the pollex or hallux or both, so formed as to be opposable to the other digits and suitable for grasping. They have also a more or less developed third or "posterior" cornu to each lateral ventricle. None of them are powerful enough to be able to successfully contend with the largest of the cats or bears, and but for his intelligence, man himself would be quite unequal either to fly from or destroy such creatures. Even as it is, many human lives are annually destroyed by the largest carnivora. In the Primates, the placenta is never in the form of a zone round the ovum.

The Carnivora differ from the *Ungulata* in that they have often five (always at least four) digits to each paw. Their digits are also unguiculate and never sheathed in horny hoofs. Their molar teeth also are either cutting or simply tuberculate, while the fœtus is developed by means of a deciduate placenta almost always in the form of a zone round the ovum. The Carnivora also are always digitigrade or plantigrade, never "unguligrade," *i.e.*, they never walk upon enormous nails (or "hoofs") as is the case with almost all the Ungulates.

The Carnivora differ from the *Rodentia* in that they have canine teeth and have not got large incisors growing from permanent pulps. They also have the glenoid cavity for the mandibular condyle transversely, and not, as in Rodents, more or less antero-posteriorly extended. Moreover, though the Rodents have a deciduate placenta it is never zonary.

The *Insectivora* differ from the Carnivora by their less perfectly developed brain, not only the cerebellum but even the corpora quadrigemina being left uncovered by the small hemispheres, which are smooth or hardly convoluted. They have, besides, a relatively small corpus callosum and a large anterior commissure. Their molar teeth also have generally more numerous and sharply pointed prominences than in the Carnivora, and their molars are not differentiated into premolars and sectorial, followed by a tubercular form of tooth. Their bony palate is often defectively ossified, which it is

ot in the Carnivora. With one exception* they always have completely developed clavicles, which in the Carnivora are never more eveloped than in the cats. Their generative organs may be provided with a sac attached to each vas deferens close to its opening nto the urethra, *i.e.*, they may have vesiculæ seminales (which 'arnivora never have), while the testes are never scrotal, and hough the placenta is deciduate it is not zonary.

Lastly, the Carnivora differ from the *Pinnipedia* in that their hind imbs are always more or less well suited for progression on land, eing always not only capable of having the plantar surfaces applied o the ground, but also being free and not held together by integuaent down to the ankles as they are in such Pinnipedia as can pply the soles of the hind feet to the ground, which none of the rue seals can do. In these latter the hind legs are permanently tretched out in a line with the axis of the trunk and tied to the ail by a fold of integument, so that they act more like a caudal fin han like legs. Seals are also entirely destitute of an external ear r concha. In all the Pinnipedia the middle digit is the shortest in ach hind foot. The brain is very large and very much convoluted, nd there may be a very small third or posterior cornu to each ateral ventricle, while the olfactory lobes and anterior commissure re rudimentary and the lachrymal canal and bone are absent.

Altogether it may be said that the cat's ORDER—the *Carnivora*—iffers from all the OTHER MONODELPHOUS MAMMALS put together, n the simultaneous possession of the following common characters, nly some of which are possessed by the various other orders:—

(1) The brain is well developed, with cerebral convolutions (two or three around the Sylvian fissure), and a well-developed corpus callosum and small anterior commissure. The cerebral hemispheres do not cover the cerebellum, nor do they contain triradiate lateral ventricles.

(2) The eyes are well developed, with a choanoid muscle, and may have a brilliant tapetum, with an iris capable of contracting its aperture to a vertical linear slit.

(3) The ears are provided with a more or less prominent concha.

(4) The hyoid has, on each side, a short thyro-hyal and a large, segmented, anterior cornu.

(5) The carpus has a scapho-lunar bone.

(6) No extremity has less than four digits, provided with sharp, conical claws, and very often there are five digits so provided.

(7) Progression is digitigrade or plantigrade.

(8) No digit is opposable to the others.

(9) There are always well developed canines.

(10) The incisors are small, and there are always six above and six below in each jaw except in the marine otter (*Enhydris*), and in the fossil *Eusmilus*, which have each but four inferior incisors.

* The African aquatic Insectivore, named *Potomogale*.

(11) The molars are cutting or tuberculate.
(12) There is a milk dentition.
(13) The stomach is simple.
(14) The cæcum is never very large.
(15) There is never more than an imperfect clavicle.
(16) The atlas has two large transverse processes.
(17) The glenoid cavity and condyle are elongated transversely.
(18) The zygoma arches very widely outwards and much upwards.
(19) There are no vesiculæ seminales.
(20) The uterus is two-horned.
(21) The placenta is deciduate.
(22) It is almost always zonary.

§ 21. The order *Carnivora* consists of a variety of genera forming

Fig. 191.—Skull of the Panda (*Ailurus fulgens*).

nine different families, which are grouped in three sets or sub-orders. One of these sub-orders is named Cynoidea, and it contains only the family of dogs, wolves, jackals, and foxes—the family *Canidæ*. The second sub-order is called Arctoidea, and it embraces the family of Bears, *Ursidæ*, and the family of Racoons, Coati-mondi, Kinkajous, with the genus *Bassaris*—a family called *Procyonidæ*.

It also contains a third small family, *Ailuridæ*, containing only the Panda (*Ailurus*), and, perhaps, *Ailuropus*.* It comprises, fourthly and lastly, the large family of Weasels and Otters, called *Mustelidæ*.

The third sub-order of Carnivora is termed ÆLUROIDEA, and it contains four families. One of these is the large family of Civets—*Viverridæ*; another—*Hyænidæ*—is made up of the Hyænas, with the aberrant Hyæna-like form *Proteles*. The third—*Cryptoproctidæ*—contains the singular Madagascar animal the Foussa, and the fourth and last family is the family of Cats, *Felidæ*.

§ **22.** If we compare the cat's SUB-ORDER *Æluroidea* with the *Arctoidea*, we find that some Arctoids differ strangely from the cat, especially the aquatic kinds, such as the otter, and above all the sea-

Fig. 192.—SKULL OF THE BEAR (*Ursus arctos*).

otter. Many, like the bear and badger, are completely plantigrade. Some have teeth which are not at all sectorial, as the bears, coati and *Ailurus*; while others, as the glutton (*Gulo*), have teeth which much resemble the cat's in structure. There is at least one hinder tubercular molar above and below, so that there are two true molars in the lower jaw.† In size the Arctoidea range from the smallest weasel to the grisly bear. Some Arctoids are frugivorous animals, as the sloth bear; others are most blood-thirsty, as the weasels, ferrets, and glutton.

With such varieties of form and habit, it is not surprising that good positive characters by which the species of a group so various may be united together, and at the same time divided off from the other sub-orders, are difficult to find. Rather, perhaps, is it surprising that any should be found at all. Yet good distinctive characters of a more or less recondite kind have been established.‡

* See Milne-Edwards's Recherches des Mammifères, 1874, p. 321, plates 50 and 56. "Ailuropus" is a curious mammal (intermediate in some respects between the Panda and the bears), which was discovered in Thibet by the Rev. Père David, the well-known French Lazarist Missionary.

† With the exception of the Patagonian weasel, called *Lyncodon*.

‡ Partly by the late Mr. H. N. Turner (too soon lost to science—a victim to a dissecting wound), and secondly by Professor Flower, F.R.S. See the Proceedings of the Zoological Society for 1848, p. 63; and for 1869, p. 4.

If we examine the *basis cranii* of a bear (Fig. 193) we see that its auditory bulla consists of a single bone, instead of two as in the cat. It is but little prominent, but is much prolonged outwards as the

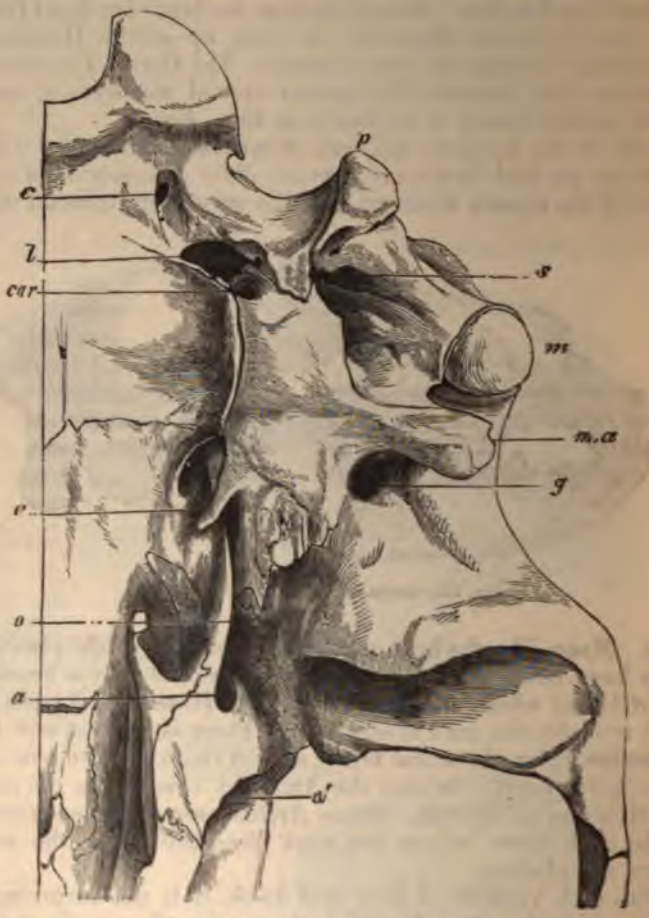


Fig. 193.—Part of Basis Cranii of Bear (*Flower*).

a. Posterior opening of all-sphenoid canal.
a'. Anterior opening of same canal.
c. Condyloid foramen.
car. Carotid foramen.
e. Eustachian canal.
Immediately above the right-hand end of the line leading from the letter e, is a large opening—the foramen lacerum anterius—at which the carotid artery reappears, after having traversed the petrosal, and bending round the skull to re-enter the skull at foramen.
g. Glenoid foramen.
l. Foramen lacerum posterius.
m. Mastoid process.
ma. Meatus auditorius externus.
o. Foramen ovale.
p. Par-occipital process.
s. Stylo-mastoid foramen.

floor of the bony meatus auditorius externus (*ma*). Towards its hinder inner end is a considerable foramen (*car*) for the internal carotid artery, which here enters the petrosal, and having traversed

, emerges at the foramen lacerum anterius (just within and ehind the opening of the Eustachian canal), and bending round e-enters the skull, in a backward direction, at the same foramen. The paroccipital process (*p*) is somewhat triangular, and projects lownwards, outwards and backwards, standing quite aloof from the ulla. The mastoid process (*m*) is widely separated from the par-ccipital, and is more or less prominent. The condyloid foramen (*c*) an be plainly seen, and is not sunk into a common opening with ie foramen lacerum posterius. A foramen which gives exit to a in—the foramen glenoideum (*g*)—is conspicuous just in front of the eatus auditorius externus. A large canal is formed by the ali-henoid, which throws out a lamina of bone to embrace the external rotid artery. The passage thus enclosed is (as has been before

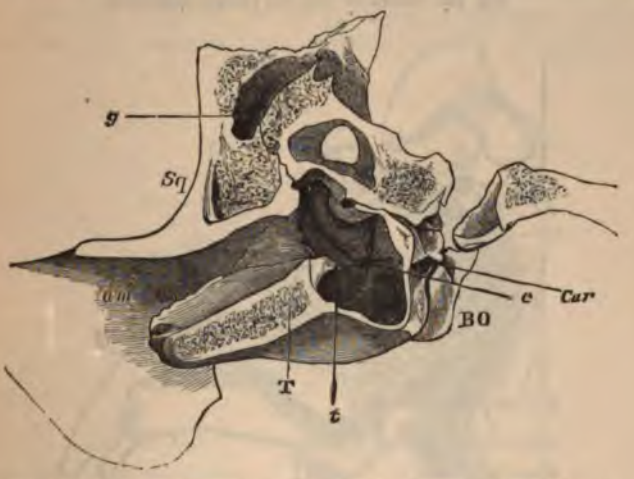


Fig. 194.—Vertical Section through Tympanic Cavity of Bear (*Flower*).

am. Meatus auditorius externus.
BO. Basi-occipital.
Car. Carotid canal.
c. Eustachian canal.
g. Glenoid canal leading to glenoid foramen.
Sq. Squamosal.
T. Tympanic bone.
t. Tympanic ring.

nentioned) called the *alisphenoid* canal. Its posterior aperture (*a*) s its own exclusively, but its anterior opening (*a'*) includes within t that of the foramen rotundum.

When the auditory bulla is seen in section (Fig. 194), the simplicity f its cavity is apparent.

The above-given cranial characters are, with the exception of that f the presence of an alisphenoid canal and of the emergence nteriorly of the internal carotid artery, characters of the whole of ie Arctoidea,* and to them may be added the further distinctions, iat there is no cæcum whatever to the intestinal canal; that the enis contains a large bone, which is not grooved, but which is dilated

* Certain exceptional details are presented by *Ailuropus*.

Fig. 195.—Skull of the Fox (*Vulpes bengalensis*)

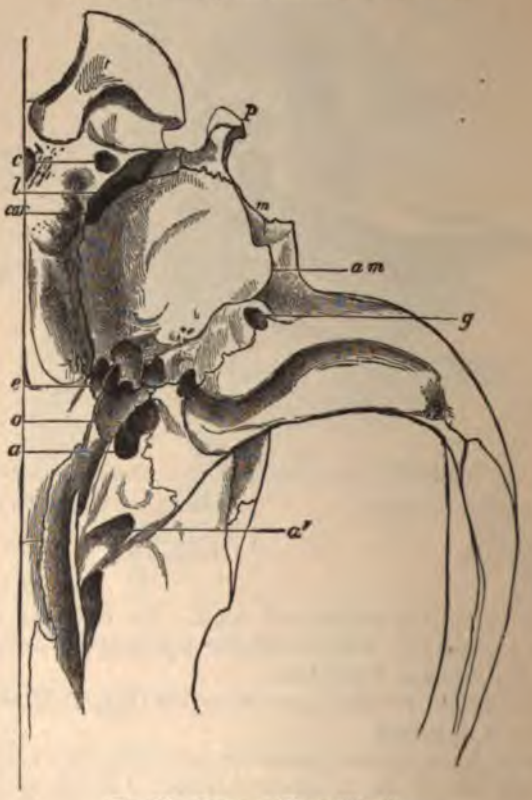


Fig. 196.—Skull of Wolf (*Flower*).

a. Posterior opening of ali-sphenoid canal.
a'. Its anterior opening.
am. Meatus auditorius externus.
c. Condyloid foramen.
car. Carotid foramen.
e. Eustachian canal.
Above the right-hand end of the line which leads from the letter e, is the foramen lacerum anterius, where the internal caro emerges, and then doubling back, re-ent the cranium.
g. Glenoid foramen.
l. Foramen lacerum posterius
m. Mastoid foramen.
o. Foramen ovale.
p. Par-occipital process.

behind and bilobed in front; that there are no Cowper's glands, and that the prostate is rudimentary, or exists only as a thickening of the wall of the urethra, and does not form a distinct prominence.

The sub-order of dog-like creatures, the *Cynoidea*—which contains but one family, *Canidæ*—differs strikingly from the cat's sub-order. The Cynoids have two posterior tubercular molars above and below, and their normal dentition consists of four premolars and two molars in the upper jaw, and four premolars and three molars in the lower jaw; though one singular form, *Otocyon*, has four premolars and three molars on each side of each jaw. If we examine the *basis cranii* we find a smooth, rounded and simple auditory bulla, but neither does it send out externally so prolonged a process (Fig. 196, *am*) for the meatus auditorius externus, as in the *Arctoidea*, nor is the carotid foramen (*car*), though of good size, distinctly visible on its inner border, for that foramen is, as it were, withdrawn within the foramen lacerum posterius, into which it opens. Nevertheless, the

Fig. 197.—Section of Auditory Bulla of Dog (*Flower*).

am. Meatus auditorius externus.
BO. Basi-occipital.
car. Carotid canal
e. Eustachian canal.
g. Glenoid canal.
s. Septum.
Sq. Squamosal.
T. Tympanic bone.
t. Tympanic ring.

internal carotid follows the same course and emerges anteriorly (there doubling backwards), as in the bears. The paroccipital process (*p*) is long and projecting, and its anterior surface is more applied against the bulla than in the Arctoid sub-order. The mastoid (*m*) is distinct, but small. Both the condyloid and glenoid foramens are very conspicuous, the former opening upon a bony ridge, and being quite distinct from the foramen lacerum posterius. There is a well-developed alisphenoid canal (*a*, *a*). When a section is made of the bulla (Fig. 197) a very incomplete septum (*s*) may be seen to spring from its anterior wall, in the same position as that in which we saw the complete septum of the cat to take origin.

These cranial characters are possessed by all the *Cynoidea*, as are also the following ones:—The cæcum is not only present, but rather elongated, and almost always folded on itself. The bone of the

penis is straight, wide, depressed and grooved. There are no Cowper's glands, but there is a salient prostate.

Finally, we come to the cat's sub-order, the ÆLUROIDEA. Therein the following characters (which we have already seen to exist in the cat) exist universally, so far as the structure of its component species is known.

(1) The auditory bulla is much dilated, smooth, rounded, and generally divided into two chambers by a septum.

Fig. 198.—SKULL AND DENTITION OF PARADOXURUS CROSSII.

(2) The bony meatus auditorius externus is short, and only produced in front, or else is imperfectly ossified below.

(3) The paroccipital process is, as it were, flattened against the auditory bulla, to which it is much more closely applied than it is in the *Cynoidea*.

(4) The mastoid is never salient, and often not to be distinguished.

(5) The carotid canal is generally small, and the foramen leading to it inconspicuous.
(6) The condyloid foramen almost always opens into the foramen lacerum posterius, and is therefore inconspicuous and concealed.
(7) There is generally no glenoid foramen.
(8) The cæcum is small and simple, and may occasionally be absent.
(9) The bone of the penis is almost always small and irregularly shaped, and may be wanting.
(10) There are Cowper's glands.
(11) There is a salient, lobed prostate.
(12) The teeth are never as tubercular as in the dogs and bears.
(13) An ali-sphenoid canal may be present or absent.

§ **23.** In considering creatures which make up the cat's own sub-

199.—The African Civet (*Viverra civetta*) (*Flower*).
a. Ali-sphenoid canal.
am. Meatus auditorius externus.
c. Condyloid foramen.
car. Carotid foramen.

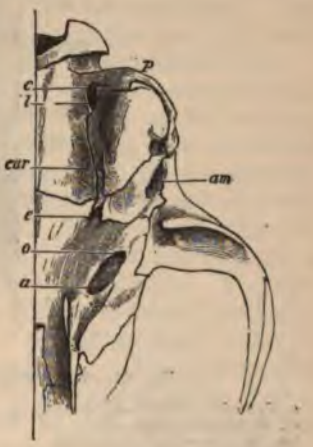


Fig. 200.—The Paradoxure (*Paradoxurus bondar*) (*Flower*).
e. Eustachian canal.
l. Foramen lacerum posterius.
o. Foramen ovale.
p. Par-occipital process.

der, it may be well to begin with the large family of the Viverridæ. his family includes a large number of forms, such as the African vet and the Asiatic zibet (*Viverra*); the genets (*Genetta*), of which ie is an inhabitant of Europe; the paradoxures (*Paradoxurus*), imals inhabiting Eastern India; the ichneumons (*Herpestes*); the ricate (*Ryzæna*); the mangue (*Crossarchus*); the animal named *nictis*; the long-whiskered, short-tailed creature, *Cynogale*, and

the large, arboreal, and in many respects exceptional Viverrine—the Binturong (*Arctitis*).

The *Viverridæ* have a rather elongated head and muzzle, and they have almost always two tubercular molars in the upper jaw and one in the lower. Of true molars (as distinguished from premolars) there are two above and two below on each side of each jaw. The teeth may vary in shape, from largely sectorial—though never as in the cats—to mainly tubercular. The cæcum is small and simple, or may be, by very rare exception, absent. Cowper's glands are present, and the prostate gland is salient and lobed. The penis may be devoid of any bone, or if there is one it is small and irregular in shape. Often, as in the civet, there are largely developed scent-glands.

In the cranial characters the whole of the Viverrines show great

Fig. 201.—THE ICHNEUMON (*Herpestes ichneumon*) (*Flower*).

a. Posterior end of ali-sphenoid canal.
a'. Its anterior termination.
am. Meatus auditorius externus.
c. Condyloid foramen.
car. Carotid foramen.
e. Eustachian canal.
l. Foramen lacerum posterius.
m. Mastoid.
o. Foramen ovale.
p. Par-occipital process.

uniformity. There is generally a distinct ali-sphenoid canal. The auditory bulla is large, smooth and rounded, and consists of two portions separated by a nearly complete septum, much as in the cat, except that the chamber which corresponds with the inner chamber of the cat's bulla, is posterior in situation. The carotid canal is larger than in the cat, and may run through a canal in the petrosal (as in *Herpestes*), or may be merely represented by a groove on the inner side of the auditory bulla. In *Herpestes* and allied forms the artery, after emerging, runs along for a short distance before re-entering the cranium. The par-occipital process is widened, spread out, and closely applied to the posterior surface of the

itory bulla, and the condyloid foramen is concealed within the men lacerum posterius. There is either no glenoid foramen t is minute. The mastoid process is quite indistinct, or but little minent. The bony meatus auditorius externus is either very rt—extending but little outside the tympanic ring (as in Viverra, . 199)—or if, as in the Suricates, it is prolonged, its floor is dianly fissured.

The next family is that of the Hyænas, HYÆNIDÆ, which also tains the curious and aberrant South African mammal, the Aard-rk (*Proteles*) an animal erroneously supposed by some naturalists be related to the dog.

In this family the teeth are either, as in the hyænas, remarkable r their strength and cutting power, or, as in *Proteles*, for their treme weakness. In the hyæna there are four upper premolars, l sectorial, especially the hindmost, which is much like that of the t, as is also the minute, solitary upper tubercular molar. In the wer jaw there are three premolars and one molar—all sectorial te those of the cat, though less perfectly formed for cutting, cause the hyæna's teeth are broader and stronger, and more suited r the bone-crushing action in which they are employed. The ard-vark has four weak, small molar teeth in either jaw, each such th being separated by a diastema from the tooth nearest to it.

As to the structure of the skull, the hyænas have a smooth, oval, minent bulla, which is perfectly simple within its cavity, not even owing a trace of a septum for its division into two chambers. et, as in the Viverrines, it is considerably more prominent posteriorly an in front, so that if a septum was developed, the chambers would obably be placed one in front and one behind. There is no ali-sphenoid nal. The carotid foramen (Fig. 202, *car*) is small, and situated a tle behind the middle of the inner margin of the bulla. The par-cipital process is spread out over the posterior surface of the bulla, at forms also a rounded prominence projecting b ckwards (*p*). he mastoid process is also slightly prominent. The bony meatus uditorius externus is short, yet the anterior portion of its floor is oduced outwards as a rather pointed process. The condyloid ramen is concealed, and the glenoid foramen is minute or absent.

Proteles agrees with the hyænas in these cranial characters, except at in it the bulla is divided by a septum into two chambers—one ing quite anterior and the other posterior—and that the mastoid d paroccipital processes do not stand out from the skull. As to the merative organs, Cowper's glands and a salient prostate are present both *Proteles* and *Hyæna*, while no bone has been observed in the nis of either. In both, also, the cæcum coli is simple and very all, and there are large scent-glands. In both, also, there are rmally not less than fifteen dorsal vertebræ.

The third family, CRYPTOPROCTIDÆ, contains only a single species -namely, a fierce animal (of the size of a large cat) to which the atives of Madagascar give the name "Foussa."

It is an animal much like a cat, but with a longer head. It has

large ears and a long tail. Its claws are retractile, but it does not walk like the cat on its toes, but applies nearly the whole plantar and palmar surfaces to the ground. It may therefore be said to be plantigrade. It was originally made known to science, and named in a paper published by Mr. E. T. Bennett.* The young specimen described by him came from Mr. Telfair of Mauritius, who declared

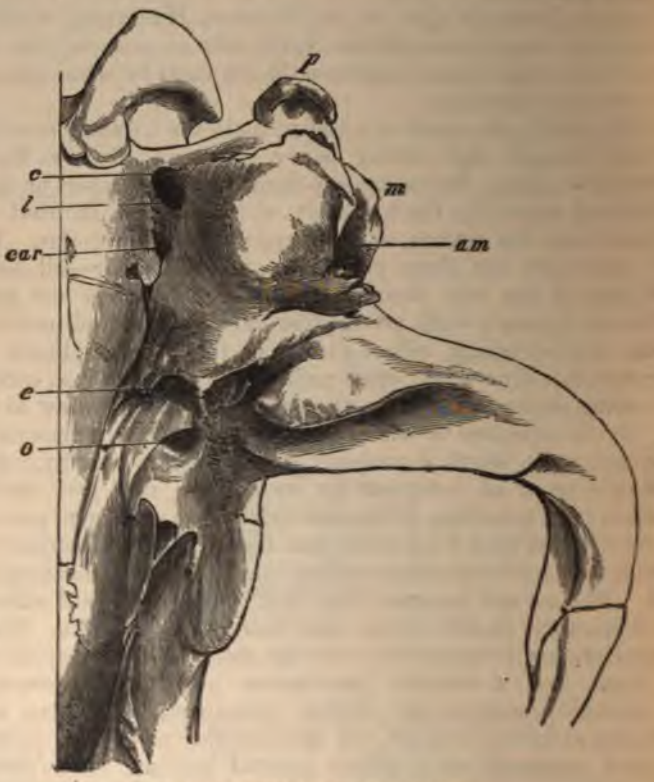


Fig. 202.—Hyæna (*Hyæna striata*) (*Flower*).

am. Meatus auditorius externus.	*l.* Foramen lacerum posterius.
c. Condyloid foramen.	*m.* Mastoid.
car. Carotid foramen.	*o.* Foramen ovale.
e. Eustachian canal.	*p.* Par-occipital process.

it to be "the most savage creature of its size I ever met with; its motions, power and activity are those of a tiger, and it has the same appetite for blood and destruction of animal life."

Its teeth are very like those of the cat, save that it has an additional premolar below and, for a time also, one above, but the latter soon falls away.

The skull is more elongated, in proportion to its other dimensions, than is that of the cat.

* In the Transactions of the Zoological Society, p. 137, plate 21.

ıe *basis cranii* (Fig. 205) shows a distinct ali-sphenoid canal (*a*, *a'*) carotid foramen near the anterior end of the inner margin of the , which is divided by a septum into two chambers. The inner

Fig. 203.—The Fossa (*Cryptoprocta ferox*).

ese chambers is quite posterior in situation, and the bulla is more prominent behind than in front. The paroccipital ss is not prominent, but is applied to the bulla, and the mastoid

Fig. 204.—Skull of *Cryptoprocta ferox*.

ss does not project outwards. The condyloid foramen is con-d, and there is no glenoid foramen.
e dorsal vertebræ are thirteen in number, and the lumbar are
.

The scapula is less rounded than that of the common cat, but there is a largely-developed metacromion. The supra-condyloid foramen of the humerus is extremely large. The metacarpals and metatarsals are relatively shorter than in the cat. The pollex is more developed, but the hallux is very different, being completely

Fig. 205.—Basis cranii of *Cryptoprocta ferox* (*Flower*).

a. Posterior opening of all-sphenoid canal.
a'. Its anterior opening.
am. Meatus auditorius externus.
c. Condyloid foramen.
car. Carotid foramen.
e. Eustachian canal.
l. Foramen lacerum posterius.
o. Foramen ovale.
p. Par-occipital process.

Fig. 206.—The Pads of the Feet of Fossa (*Cryptoprocta ferox*).

A. The sole of the fore-paw.
B. The sole of the hind-paw.

formed, instead of being, as in the cat, a mere rudiment. It has a long metatarsal and two phalanges, the distal end of the digit reaching nearly to the distal end of the first phalanx of the adjacent toe.

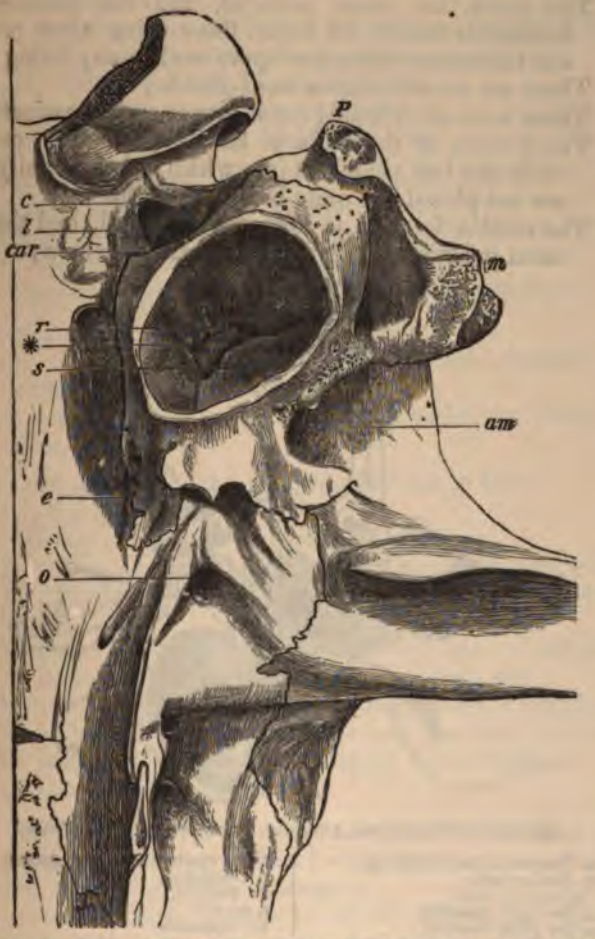
The naked pads on the feet are much more extended than in the cat,* in harmony with the almost quite plantigrade habit of the Fossa. There is a long bone to the penis, compressed, slightly curved, not grooved, but slightly dilated at each end, more so posteriorly.

The anatomy of the soft parts is, unfortunately, as yet unknown.

§ **24**. Such being the nature of the families of the cat's sub-order,

* See *ante*, Figs. 9 and 10, p. 25.

ier than the family of cats themselves (*Felidæ*), we may now ıtrast the latter (*i.e.*, the *Felidæ*,) with each of the former. The different kinds of cats all agree with the common cat in



207.—PART OF THE BASE OF THE SKULL OF THE TIGER (*Felis tigris*). A PORTION OF THE AUDITORY BULLA HAS BEEN REMOVED TO SHOW ITS INTERIOR. THE CAVITY OF THE INNER OR POSTERIOR CHAMBER IS EXPOSED (*Flower*).

am. Meatus auditorius externus.
c. Condyloid foramen.
car. Carotid foramen.
e. Eustachian canal.
l. Foramen lacerum posterius.
m. Mastoid process.
o. Foramen ovale.
p. Par-occipital process
r. Fenestra rotunda.
s. Septum between the chambers.
* The aperture of communication.

ucture, save as regards the details already pointed out in the last ıpter. We may then proceed to sum up the main points in which cat's FAMILY differs from the other three families of the sub-ler *Æluroidea*, as follows.

The FELIDÆ differ from the VIVERRIDÆ, in that in the *Felidæ*:

(1) The head is more rounded;
(2) The limbs are generally longer in proportion to the trunk;
(3) The claws are generally more completely retractile;
(4) The teeth are more sectorial, and the premolars and tubercular molars are fewer, there being never more than one tubercular molar (an upper one) in any living species;
(5) There are no conspicuous scent-glands;
(6) There is no ali-sphenoid canal save in certain extinct genera;
(7) The division of the bulla is hardly perceptible exteriorly, while the two chambers into which it is internally divided are not placed one quite behind the other;
(8) The carotid foramen is always very small, and the carotid canal indistinct, except in some extinct genera;

Fig. 208.—SECTION OF THE AUDITORY BULLA OF THE TIGER (*Flower*).

am. Meatus auditorius externus.
BO. Basi-occipital,
e. Eustachian canal.
i c. The inner chambers.
o c. The outer chamber.
* The aperture of communication between the chambers.
Pt. Petrosal.
s. Septum.
Sq. Squamosa

(9) The par-occipital process (though applied to the bulla) may in large species, develope a marked process;
(10) The meatus auditorius externus is never medianly fissured below.

The FELIDÆ differ from the HYÆNIDÆ in that:

(1) Their head is more rounded;
(2) Their claws are retractile;
(3) The body does not droop so much posteriorly;
(4) The teeth are more perfectly sectorial in form;
(5) The premolars are less numerous;

(6) The bulla is, at least in existing species, divided into two chambers, which are not placed completely one behind the other;
(7) The bulla is most prominent towards its inner, not towards its hinder border;
(8) The bony meatus auditorius externus is not produced anteriorly into an outstanding process;
(9) There may be a small bone to the penis;
(10) There are no conspicuous scent-glands;
(11) There are only thirteen dorsal vertebræ.

The FELIDÆ differ further from the TRUE HYÆNAS (*i.e.*, the Hyænas as distinguished from *Proteles*) in that:
(1) Their teeth are less powerfully formed for crushing;
(2) The bulla is divided by a septum;
(3) The carotid foramen is generally still less conspicuous.

They further differ from *Proteles* in that:
(1) Their teeth are much stronger and larger relatively, and more closely approximate;
(2) The chambers of the bulla are not quite one behind the other.

The FELIDÆ differ from the CRYPTOPROCTIDÆ in that:
(1) They are quite digitigrade;
(2) Their skull is relatively shorter and rounder;
(3) Their premolars are (except in *Archælurus*) less numerous;
(4) The chambers of the bulla are not quite one behind the other;
(5) There is no ali-sphenoid canal, save in some extinct genera;
(6) The supra-condyloid foramen is of moderate size;
(7) The metacarpals and metatarsals are relatively longer;
(8) The pollex is very small, and the hallux a mere rudiment;
(9) The naked pads of the feet are much less extended;
(10) The bone of the penis is small.

§ **25**. We have now before us as complete a statement as the author can give of the relations which exist between the cat's family and all other living organisms whatsoever.

As to the subordinate groups contained within the cat's own family, *i.e.*, its genera, we saw in the last chapter that all known cats living and extinct can be arranged in eleven sets of kinds, to which the names *Felis*, *Cynælurus*, *Ælurodon*, *Archælurus*, *Dinictis*, *Nimravus*, *Pseudælurus*, *Hoplophoneus*, *Pogonodon*, *Machærodus*, and *Eusmilus*, have been given. We now see what was meant by saying that these groups have each the value of a "genus." As to the relations which exist between the feline genera, we now also see that the exceptional characters presented by *Dinictis* and *Archælurus* are peculiarities which cause those genera to have a certain resemblance to the Viverrine family.

In the last chapter we recognized the fact that an extreme

specialization of structure is presented by *Machærodus* and *Eusmilus*, and that *Cynælurus* is the most exceptional form amongst living felines, and one in which some of the distinctive characters of its family (*e.g.*, the retractility of the claws), are poorly developed. The cat's genus, *Felis*, is one which, while it well exemplifies the characters of the family to which it belongs, yet does not exhibit any of those characters developed either in an extreme or in an aberrant manner. This statement needs some explanation. Every group of animals containing various species consists of certain kinds, which are more or less alike, and differ but little from an ideal standard which is the type of such group. Such kinds are *normal* forms. Besides these, there are generally certain other kinds which are peculiarly modified in one way or another, departing more or less widely from the normal structure. Such divergent kinds are said to be *aberrant* or *abnormal*. Also both "normal" and "aberrant" forms may be either what is called *specialized* or *generalized*. "Specialized" creatures are such as have an exceptional organization of a definite kind. "Generalized" creatures are such as resemble the general run of animals to which they are more or less closely related, but have the distinctive characters of their group poorly developed. But besides the specialized and generalized normal forms, there may be other normal forms which are neither of these, but adhere closely to the type and express it in its intensity, yet without any one-sided development of it. These are TYPICAL FORMS. The full meaning of these terms can only be made clear by examples, for which it is necessary to refer to some other group of animals with which the reader may be acquainted, or with which he can easily become so. Let us then take, as examples, species of the well-defined group of ruminating beasts. Amongst them we have creatures which adhere to the normal structure, but yet its characteristic features are in them but poorly developed. They are then *generalized normal forms*, as, *e.g.*, that small South American deer, the yenada or pudu (*Pudu humilis*). Others, which adhere to the normal structure, may carry it to an intense but some-what one-sided degree of development. Such would be *specialized normal forms*, as, *e.g.*, the elk or the four-horned antelope. Others again may diverge from the general type in the direction of other creatures outside their group. Such would be *generalized aberrant forms*, such as the camel and llama, or as the chevrotains; while others may diverge from such type in a special direction of their own, and such would be called *specialized aberrant forms*, as, *e.g.* the giraffe.

Finally, others will be normal, and yet with the characters specially to the group strongly developed, *i.e.*, they will be *typical forms*, as *e.g.*, the red deer or the Indian antelope.

To apply these remarks to the *Felidæ*, we have an example of a "generalized normal form" in the cheetah, *Cynælurus*. The lion is an example of a "specialized normal form." For a "generalized aberrant form" we must have recourse to fossils, such as *Dinictis*

and, above all, *Archælurus*, as also for *specialized aberrant forms*, of which *Eusmilus* and *Machærodus smilodon* afford us excellent examples. Finally, as the expression of the *typical* or fully-developed normal form of the cat's family, we have the species which go to make up the maneless cats of the typical genus Felis, of which *Felis catus* will stand as a very good example.

But if the cat is thus the typical genus of its family, in what relation may its family be said to stand to the other families of its order thus considered? Of all the families of that order, the dog's family, *Canidæ*, seems to be the most *generalized aberrant* one. For while it possesses the general characters of its order without carrying them to an intense degree, it shows certain resemblances to forms outside its order.*

The bears, on the other hand, are *specialized aberrant forms*, as they depart from the normal standard of the order in a special direction of their own, as also do the otters and several other forms of Carnivora.†

As to the mass of the Mustilidæ and Viverridæ, they may be considered to be *normally generalized* carnivores, since they possess the ordinary carnivorous characters moderately developed. It is not easy to point out any certainly *normally specialized* families—any family, that is, which has the characters of the order in an intense degree, but developed, as it were, in a one-sided manner. Such characters seem only present in certain exceptional *Felidæ*, such as *Machærodus* and *Eusmilus*. If so, then the *Felidæ*, as a whole, must be held to be the *typical* family of the whole order; for they carry the carnivorous type of structure to an intense degree, but one which is in the direct line of development which the order Carnivora has followed. Carnivorous beasts generally have sharp claws, often more or less retractile, but none have them so perfectly developed in these respects as have the cats. Almost all carnivorous beasts have teeth more or less well adapted for killing prey and cutting flesh, but none have their teeth so admirably adapted for these purposes as have the cats. The cats are then carnivora *par excellence*, and they carry out the type of their order to its highest-known and most perfectly harmonious expression.

But the cats are not only such highly-developed Carnivora. Something may also be said in favour of their being the highest of mammals—the very flower and culmination of the mammalian animal tree.

Spontaneous activity and sensitiveness are the special characteristics of animal life, and with both these powers the cats are largely endowed. We have recognized the perfection of their organs of movement, and that of the very substance of their bones and muscles, as well as the great perfection of their special senses. It may be objected, however, that the activities and sense perceptions of certain other beasts

* *E.g.*, to certain marsupials.

† Such as *e.g.* the kinkajou (*Cercoleptes*), the binturong (*Arctitis*), and also *Proteles*.

are, in their own various ways, as highly developed as are those of the *Felidæ*. It is certainly very true that it is only through the possession of perfectly-formed bones and muscles, of a delicate sense of hearing, or of far-reaching vision, that antelopes, hares, and such creatures, escape their carnivorous pursuers. But then they use their organization for *escape*. The organization of the cat-tribe may then be deemed superior, because it is not only excellent in itself, but because it is fitted to dominate the excellences of other beasts. Thus considered, the Carnivora would rank first amongst mammals, and the cats would rank first amongst the Carnivora. Man, however, is a mammal, and therefore to affirm this would be to affirm the inferiority of our own species. But man's superiority is mental, it resides in his intellect, not in his peculiarly-formed great toe, hand, pelvis, or other corporeal peculiarity. Man is to be regarded in two lights—as a truly intellectual being, and as animal with a certain organization. Viewed in the first mode, he stands quite apart from and outside of the whole visible creation, and has simply no place whatever in any scheme of biological classification. Considered merely in his capacity as an animal, he has a very definite place in such a scheme, but it is by no means certain that his place is at its summit. Our powers of locomotion and of sense perception are quite inferior to those of very many beasts, and though our brain is large, both absolutely and relatively, yet such are the variations in this respect, presented by animals of different groups and by different animals of the same group, that the naturalist would be a bold one who should venture to affirm that a brain-classification of vertebrate animals—to say nothing of the Invertebrata—would be a satisfactory one. The close bodily resemblance of apes to man gives them then no just claim to a rank above that of the Carnivora, since such a claim only reposes on their bodily resemblance to ourselves. As to their intelligence, no evidence seems to be forthcoming that it is superior to that of the dog or of the elephant, though the close likeness to ourselves gives to their tricks a deceptive appearance of rationality which we must always be careful adequately to discount if we would correctly estimate their real worth.

The apes are, like the dogs and the elephant, superior perhaps in cognitive psychical endowments to the cat, but yet any such differences between these animals are merely differences of degree and not of *kind*, like that which we have seen to exist between the cat-mind and our own.

It may, perhaps, be objected to these observations, that biological classification is (as has been pointed out in this work) a morphological and not a physiological classification; that it reposes not on function but on structure. This is most true, and nothing could well be more preposterous than a proposal to classify all creatures according to their psychical endowments. Such a classification would tear away ants and bees from insects obviously like them, and associate them with beavers, and it would utterly confuse all biological science. But though it is true that animals must be classified according to

ir structural characters, yet it is obvious that the value of and the ations between structural characters themselves, cannot be con-ered except by reference to conditions which are *not* structural. erefore, as in considering the question, which of all the groups of imals is to rank highest, we must estimate the *value* of their *uctural* characters, we must necessarily, in so doing, go beyond ts of structure themselves, *i.e.*, we must refer to the purposes they ve, that is to physiology.

It is therefore true that "something may be said in favour of cats ing the highest of mammals," if man is considered merely in his imal capacity—in which alone he can be brought into comparison th other organisms.

But whether or not this eminence be allowed to the cat, there can no question but that it is the most highly-developed type of rnivorous mammalian life—the most perfect embodiment of the ea of a "beast of prey." Such, then, is *certainly* the "CAT'S PLACE NATURE:" It is a member of the typical genus of the typical mily of carnivorous placental mammals—mammals being the suck-ring, tied-brained * class of back-boned animals.

* *I.e.*, with their cerebral hemispheres united by means of a corpus callosum.

CHAPTER XIV.

THE CAT'S HEXICOLOGY.

§ 1. EVERY animal has definite relations to the various influences which on all sides surround and act upon it, and which constitute what is called its "ENVIRONMENT." Every animal has existed for a certain definite time and within certain limits of space. It has been favoured, or the reverse, by the physical forces (that is, by conditions of climate, including temperature, moisture, &c.), and its existence has been related in various ways to that of other living creatures. The science of *Hexicology* is (as was shortly stated at the end of the first chapter) the study of all these more or less complex relations.

§ 2. The cat-group, *Felidæ*, has now to be considered as thus related to its environment, and we may consider first its relations with PHYSICAL CONDITIONS.

As to *heat*, that the domestic cat loves warmth is what everyone must have observed. Almost all the larger cats, and the great bulk of the smaller kinds, are inhabitants of the warmest regions of the globe. No cat dwells in the extreme north with the polar bear, while no region is too hot for certain species of *Felis*.

Yet we have seen that the Ounce and *Felis scripta* are dwellers on the snowy heights of Thibet, and that the tiger ranges to the Amoor river, while the group of lynxes—the caracal excepted—and northern forms, two varieties, possibly two species, being found in Scandinavia and Canada. Moreover, in earlier times, existing species, such as the lion, extended into colder climes than they now inhabit, while in the earliest prehistoric human period that great cat *Felis spelea*, was an inhabitant of England, protected perhaps by a very ample furry coat, such as that which protects the Ounce of Thibet to-day. Yet the differences as to fur are after all very small compared with the differences as to climate. Therefore, the feline race being thus able to live in countries of very different temperatures, must have a considerable internal power of regulating and sustaining the temperature of the body, and concomitantly with this faculty we find that no cat falls into a winter sleep, *i.e.*, no cat hibernates.

As to *light*, though the great majority of cats dwell in climates where daylight is intense, yet they mostly remain in repose while the sun is above the horizon, and prowl about in twilight or at night.

Still certain kinds are diurnal, and from observations made at the

ological Gardens it seems that it is (as might be expected) the ts with pupils which can be contracted into minute linear openings hich are the most nocturnal. Yet the tiger in spite of its circular pils seeks its prey at night.

With regard to *moisture*, though no cats are aquatic, and though ne take to the water save with more or less (generally with treme) reluctance, yet many (like the tiger and the jaguar) abitually haunt the banks of rivers or pools, because they more sily obtain their prey in such situations. Certain kinds, more- er, live more or less upon fish (as *F. viverrina*), and the domestic t's relish for fish is very marked. Yet the *Felidæ* are a family of ther distinctly terrestrial or else arboreal mammals.

The *Felidæ* as a rule do not drink much water, but it seems* that e smaller kinds drink more in proportion to their size than do the rger species. The lion is found in desert regions, and when in ptivity drinks very little.

As to the degree of rarity of the atmosphere which they can dure, we have seen that the Ounce ranges from 9,000 to 18,000 et—the latter altitude being one at which man breathes with much fficulty.

§ 3. The GEOGRAPHICAL RELATIONS of the cat-family are instructive d somewhat complex. As was long ago remarked by Buffon, the eat cats of the Old and New Worlds are markedly distinct. The or, tiger, leopard, ounce, clouded tiger, cheetah, and caracal, with variety of smaller cats, are all inhabitants of the Old World only. he puma, jaguar, ocelot, jaguarondi, eyra, collocollo, the pampas, and e or two other cats are exclusively inhabitants of the New World. is only amongst the lynxes that we find a form which is common both these worlds—the Canadian and North European lynxes being robably but varieties of one species. With this exception no wild t found in America is also found out of it. The New World is not rich in cat-species as is the Old, nor do its largest kinds, the puma nd jaguar, equal the largest kinds of Africa and Asia.

A further geographical distinction may be drawn amongst Ameri- an cats themselves. Of its varieties of lynx, *F. maculata* descends s far south as Mexico, while the puma alone extends to high latitudes n both North and South America. We may therefore distinguish the egion north of Arkansas and Louisiana as the region of lynxes and he puma; while Mexico, with parts of Arkansas and Louisiana, and ll America south of Mexico may be said to be the region of the uma, jaguar, ocelot, and all other American cats.

Strange to say the West Indian Islands, though some of them, as Cuba and Hayti, seem admirably suited to shelter and support pecies of *Felidæ*, are entirely destitute of them.†

In the Old World, certain other geographical divisions may be imilarly established. We have seen that the lion, leopard, caracal,

* Mr. A. D. Bartlett has kindly supplied me with information as to the drinking habit in confinement of different species of the cat family.

† Trinidad is to be reckoned as a part of the South American continent.

and common cheetah certainly exist in both Asia and Africa. With these exceptions, however, the two tropical continents of the Old World seem to have a quite different cat population.

In Africa we have, peculiar to it, the serval with its allied species or varieties, *F. rutila*, *F. neglecta*, *F. servalina*, *F. celidogaster*, and *F. senegalenis*, as also *F. caligata* and *C. lanea*. Moreover, though the serval is said to occur in Algeria, and *F. caligata* is a North African form, the other varieties are found in Guinea, Gambia, Sierra Leone, and Senegal. Africa south of the Sahara may therefore be considered as richer in cats than the more northern portion of that continent, especially as it is south of the Sahara that the kinds common to Africa and Asia are principally found. There is reason, moreover, (from the analogy of the geographical distribution of other animals) to suspect that the felines now found north of the Sahara may be immigrants from the more southern portion of Africa.

Just as in America we found the West Indies to be devoid of cats, so, strange to say, the great island of Madagascar, in spite of its forests and numerous animal population, is similarly without a single species of cat.

In Asia we find a further subdivision possible between its northern, south-western, and south-eastern portions. In the north, *i.e.*, north of the Himalayas, we have the ounce, the tiger, a lynx (*F. isabellina*), the steppe cat (*F. Manul*), the leopard (in Japan), and the species or varieties before described as *F. microtis*, *F. tristis*, *F. scripta*, and *F. chinensis*.

In South-western Asia we have the lion, with certain forms common to this and other Asiatic regions, such as the tiger, leopard, Indian wild cat, and some others.

In South-eastern Asia we have the clouded tiger (*F. macrocelis*), *F. planiceps*, *F. badia*, *F. marmorata*, *F. megalotis*, *F. aurata*, *F. minuta*, with the tiger, leopard, and others common to other regions.

The tiger, as we have seen, descends through the Indian Archipelago, with the exception of Borneo, down to the island of Bali, which is its furthest limit south.

In the immense and hot island of New Guinea, in Celebes,* in Australia, and in New Zealand, there is no single indigenous cat of any kind.

In Europe, we have two species of lynx and also the wild cat, while within the historical period we had the lion also. Thus the world may be divided according to the distribution of its cat-population into two great divisions—those of the Old and New Worlds

* Müller (Verhand. over de Natuurlijke Geschiedenis Zool. Leyden, 1844, Part I., Over de Zoogdiernen van den Indischen Archipel., p. 54) speaks of reports received from natives of the existence of a panther and wild cat in Celebes. Though it is not impossible that there may be a cat in Celebes, it is extremely unlikely that one should be found in that island, and Dr. A. B. Meyer, of Dresden, writes to me to say that the animal meant is probably a Paradoxurus, which certainly exists there. He also tells me he obtained two specimens of *Felis minuta* from Zebu, in the Philippine Islands. *F. minuta* also inhabits Borneo.

spectively, with further subdivisions into: (1) America north of rkansas and Louisiana; (2) Arkansas and Louisiana, Mexico, ntral and Southern America; (3) Africa, the part north of the hara being somewhat distinct; (4) Asia north of the Himalaya;) Southern Asia—slightly separable into (A) a south-western, and) a south-eastern portion; and, finally, (6) Europe. A certain inity exists between Europe and Northern Asia on the one hand, d in a less degree, between Europe and North America on the her; while South-western Asia has a certain affinity to Africa. ne West Indies, Madagascar, the Philippines, the Moluccas, New ainea, Australia, and New Zealand, are all devoid of any natural line population, while Asia is certainly the great home of the cat mily.

Such being the geography of the *Felidæ*, what relation does it ar to the geography of other animals?

§ 4. It has been found that (regard being had to the geographical istribution of animals of all kinds) the earth's surface may be most nveniently divided zoologically (the polar regions not being included) nto the six following regions: (1) Palæ-arctic; (2) Ne-arctic; (3) ndian; (4) Ethiopian; (5) Neo-tropical; and (6) Australian.

The PALÆ-ARCTIC REGION includes all Europe, with Iceland and he Azores; Africa, north of the Sahara, with the Canaries and Cape Verde Islands; and all Asia (with Japan), north of the Himalaya nd the tropic of Cancer, except the southern part of China, Assam, nd some parts adjacent, which belong to the Indian region.

Characteristic of this region are horses and asses, mules, sheep, goats, camels, fallow-deer, the ibex, the chamois, many warblers, grouse, pheasants, tits, magpies, true vipers, chameleons, and various Batrachians, such as the gigantic salamander, the land salamander, he proteus, and various other efts, as well as many frogs and toads. Twenty genera of fresh-water fishes (belonging mostly to the carp, perch, and salmon families) are peculiar to this region. As to nsects, there are fifteen peculiar genera of butterflies. Here and here are also found certain monkeys, flying foxes, the genet, hyæna, polar bear, walrus, and hyrax.

This zoological region does not exactly correspond with our feline geographical divisions, yet it to a certain degree harmonizes with hem, embracing, as it does, the European, North Asiatic, and North African feline divisions in one.

The NE-ARCTIC REGION of general zoological geography, includes North America down to and (on elevated land) somewhat south of the tropic of Cancer. This region is destitute of apes, hedgehogs, wild horses, asses, swine, true oxen, goats, or dormice. It has hardly any sheep or antelopes, and no flycatchers, starlings, true grouse, or pheasants. On the other hand, it has peculiar forms, such as racoons, peccaries, certain antelopes, certain pouched rats, the prairie dog, certain porcupines, and also turkeys, crested quails, tufted grouse, and passenger-pigeons, the mocking-bird, the canvas-backed duck, and some humming birds. Besides these, it has rattle-

snakes, the curious lizards, *Chirotes* and *Phrynosoma*, and various terrapins, besides alligators, but no chameleons or true vipers. The tailed-Batrachians have their head-quarters in this region. Besides other genera peculiar to it may be mentioned: the *Menopoma*, *Menobranchus*, *Amphinama*, and *Siren*, as well as the axolotl. Certain ganoid fishes are also noteworthy, such as *Amia*, the bony pike (*Lepidosteus*), and *Scaphirhynchus*.

This region mostly corresponds with our North American cat-region, but extends further southwards, as our North American feline region excludes Mexico and Southern Texas, and even parts of Louisiana and Arkansas.

The ORIENTAL or INDIAN REGION embraces India, Burmah, Southern China, the Malay Peninsula and Archipelago, including the Philippine Islands and the island of Bally, but excluding Lombok, Celebes, and the islands south and east of these. Amongst its animal inhabitants are many monkeys. There are also many deer, and but few antelopes.* Elephants and rhinoceroses are found there, and also chevrotains (*Tragulus*), pangolins, and a tapir. Amongst its birds may be noted the peacock, the argus and fire-backed pheasants, true fowls, hornbills, bee-eaters, many pigeons, parrots, cuckoos, and wood-peckers, and a few sunbirds (*Nectarinidæ*). As to reptiles, we find a multitude of snakes—amongst them the cobras and curious *Uropeltidæ*, or shield-tailed snakes—but no rattle-snakes—with many lizards, including chameleons and the little flying-dragon (*Draco*). We also find crocodiles and gavials, but no alligators, while in the Indian Ocean we find sea-snakes. Frogs and toads are numerous, but efts are wanting, save as immigrants from the Palæ-arctic region. We, however, meet with the singular *Ophiomorpha*, or snake-like creatures of the frog's class, *i.e.*, of the class *Batrachia*.

This region then is a very well defined one, and corresponds with our South-eastern Asiatic feline region. It is remarkable that the island of Bally is the extreme limit of the Indian *general* zoological region as well as of the South Asiatic *feline* region.

The ETHIOPIAN REGION is made up of Africa, south of the Sahara, with Arabia, the Seychelle islands, Mauritius, and Madagascar. It agrees with India in having elephants and rhinoceroses; but zebras, quaggas, certain hogs, the hippopotamus, the giraffe, the aquatic musk-deer, and Cape ant-eater (*Orycteropus*), are all peculiarly African. Africa is also specially remarkable as the home of multitudes of antelopes of many different kinds, great herds of which range over its southern plains. There are, however, no bears, deer, true oxen, goats, or sheep. Peacocks, pheasants, and jungle fowls are also wanting amongst its birds, while in their place we find guinea fowls. The secretary bird, *Balæniceps*, the Balearic crane, and ostrich, are forms peculiar to Africa, which is also the great home of the weaver-birds and sun-birds. Reptiles abound—tortoises, lizards and snakes, amongst which latter (as in India) there are cobras, but

* Amongst them is the four-horned antelope.

rattle-snakes. Crocodiles exist, but neither alligators nor gavials. ere are no efts, but there are *Ophiomorpha*, and many frogs and ds, *Dactylethra* being the most remarkable of the latter. Amongst hes, we have the curious ganoid, *Polypterus*, and one form of *pidosiren*.

This general zoological region agrees with the corresponding feline gion, save that the latter is less distinct from that part of the con- ent which is north of the Sahara, and has nothing to do with the ands above named. Madagascar, however, is remarkable, not ly for the absence of cats, but for possessing a very peculiar imal population of lemurs and lemur-like forms, and as the me of that exceptionally cat-like Viverrine, the Foussa—*Crypto- octa ferox*.

The NEO-TROPICAL REGION of general zoological geography comprises merica south of the tropic of Cancer, together with the West Indies, d includes the greatest forest region in the world. It has a number peculiar monkeys and bats, with two river-dolphins found nowhere se. It has also the coati-mondi, kinkajou, and tapir; but there e no elephants, rhinoceroses, horses, asses, or hippopotamuses. ere are peccaries also instead of hogs. Altogether devoid of telopes, goats, sheep, oxen, or camels, there are deer and llamas. odents abound, and there are many absolutely peculiar, such as e paca, the viscacha, the chinchilla, the guinea-pig, and its gantic cousin, the capybara, preyed on by the jaguar. But the o-tropical region is remarkable for the presence of a group of imals found nowhere else whatever. This is the group comprising e sloths, ant-eaters, and armadillos. Opossums also are very merous, and of many species of different sizes, and seem to take e place of the insect-eating beasts (*Insectivora*), which are here nspicuous by their absence. Amongst Birds, we have, in the first ace, the beautiful humming-birds, with toucans, jacamars, mot- ots, todies, macaws, curassows, and tinamous. Specially note- orthy, also, are the American ostrich, or rhea, the hoazin (*Opis- ocomus*), the cariama, and the horned-senamer (*Palamedea*).

There are very many reptiles, and amongst them are both croco- les and alligators, but no gavials; an extensive family of Iguana- ke lizards, the ameiva and its allies, but no chameleon. There are any snakes, including the boa-constrictor and rattle-snakes, but no bras, or true vipers. Batrachians are represented by *Ophiomorpha* nd many frogs and toads, including the celebrated *Pipa* of Suri- am. A few efts also exist in the mountains towards the north. mongst fishes may be mentioned the largest fresh-water fish in the orld (*Sudis gigas*), the electric eel, the Trygon family of rays, and *Lepidosiren*. The very numerous carp family, however, is here nrepresented.

Thus this rich general zoological region agrees with the South merican feline region save that the latter extends further north, hile the former embraces the West Indian islands which are xcluded from the South American cat region.

Finally, the AUSTRALIAN REGION is made up of Australia, with Tasmania, New Guinea, Celebes, the Moluccas, and islands of the Malay Archipelago up to and including Lumbok, and also of New Zealand and the Polynesian Islands.

This great region is distinguished as the home of the marsupial and monotrematous mammals.

Only in the part which approaches the Indian region do we find any ape or civet cat, with an ox (the anoa), hogs, deer and some squirrels. Flying foxes, however, exist even in Australia itself. As to birds, there are no vultures or woodpeckers; or true finches or pheasants, while we have, as absolutely peculiar to the region, birds of paradise,* honeysuckers (*Melephagidæ*), lyre-birds, bower-birds, cockatoos, many parrots, the brush-tongued lories, the mound-making *Megapodius*, the emeu, the cassowary, and (in New Zealand) the apteryx. It is also *the head-quarters of the group* of kingfishers, and it has many pigeons, including the crowned pigeon and the hook-billed *Didunculus*. There are also large goatsuckers, and a variety of weaver-birds and sun-birds. A multitude of snakes exist, and very many poisonous ones, but no true vipers and no rattle-snakes. As in India, we find gavials as well as crocodiles, but no alligators. Only in the Malayan part of the region are there any land tortoises. Absolutely peculiar reptilian forms are the *Pygopus*, the frilled lizard, the Moloch lizard, and above all (in New Zealand) the lizard *Sphenodon*.† There are no *Ophiomorpha*, and no efts, but there are very many frogs and toads. As to fresh-water fishes, we have the very noteworthy *Ceratodus* (an ancient triassic form here still surviving), while both the perch and carp families are wanting.

New Zealand is very remarkable for the almost entire absence of indigenous mammalian life—marsupial, no less than placental. There, birds are almost the highest animals below man, and there, until his arrival, they held undisputed sway as represented by huge creatures belonging to the genus *Dinornis*.

The Australian region then is not merely distinguished by an absence of cats, but by the presence of an animal population which could hardly have co-existed with them. In the West Indies and Madagascar, cats may be absent merely through the accident of non-introduction into those parts of the earth's surface of a large number of mammalian forms of life, amongst which the cats were included. Yet we do find there some mammals more or less allied to cats; but their numbers are few, while the place of the Carnivora is not taken by a great variety of other forms remote from them in structure and affinity. In Australia, however, while the whole sub-class to which the *Felidæ* belong is conspicuous by its absence, it is replaced and represented by a multitude of creatures belonging to another sub-class, *i.e.*, to the *Didelphia*. Thus the Australian

* New Guinea forms.

† A last survivor of a group of forms long passed away.

region may be considered as a sort of negative feline region, the emphatically "catless" portion of the globe.

§ 5. We must next consider the relations of cats to TIME, and first with respect to individual life. The cats of largest size appear to live longest. The domestic cat lives ordinarily for about twelve years, and eighteen years is the greatest age for which the Author has obtained certain evidence. The lion is said however to live for forty years, and the well-known lion named "Pompey," which died in the Tower of London in 1760, had lived there, it is asserted, for no less than seventy years. This seems, however, to be a fable. The Author has not been able to ascertain with certainty that the lion lives beyond thirty years.

As to the period during which existing kinds of cats have lived in times geologically recent, we must have recourse to history and to deposits such as those amongst which have been found the prehistoric remains of earlier races of man. As to the existence of *Felidæ* in more ancient periods, and as to the period when genera which are now extinct flourished, evidence has to be sought for amongst the fossils contained in the rocks and deposits of different geological dates.

It has already been said that lions existed in South-eastern Europe in the time of Xerxes. These may have been survivors of the huge cat *Felis spelea* (the so-called cave lion). But whether this was the case or not, it is certain that large extinct kinds, together with the leopard and other smaller forms (including the wild cat), ranged over Europe and England in prehistoric periods of very different dates.

§ 6. Before passing in review those genera of cats which have become extinct, it may be well to state briefly some elementary facts of geology, an acquaintance with which is necessary for a correct appreciation of the relation of the cat to past time.

The outer crust of the earth consists of more or less horizontal layers of different materials deposited from salt or fresh water, and known as STRATA. In these are often contained evidences of past animal life in the shape of (1) real bones, (2) pseudomorphs or aggregations of mineral matter which have exactly taken the place of real organic objects which have disappeared, (3) moulds external or internal, or (4) casts of moulds of such objects—all these four kinds of relics being what are called "FOSSILS."

The various "strata" were of course deposited at successive times, and the time of the deposition of each is called its "period," or "epoch." But for subsequent disturbance, the most ancient strata would always be, as they generally are, the deepest.

The uppermost and most recent accumulations of sands, clays, and gravels form what are called the "recent deposits," and these are not counted as forming any part of the proper *geological strata*.

The strata beneath these are classified in three great groups, belonging respectively to three great epochs.

The first or uppermost, and least ancient group, consists of strata called the *tertiary* or *cainozoic* strata.

The second, or next deeper and more ancient group, is formed of strata, termed the *secondary* or *mesozoic* strata.

The third, or deepest and most ancient group, comprises the strata named the *primary* or *palæozoic*.

The PALÆOZOIC, or primary rocks, are made up of the following groups of strata, or "*formations*:" beginning with the oldest—1, the Laurentian; 2, the Cambrian; 3, the Silurian; 4, the Devonian and Old Red Sandstone; 5, the Carboniferous (including the Coal Measures), and 6, the Permian.

The MESOZOIC, or secondary rocks, are made up of: 7, the Triassic formation or Trias, including the New Red Sandstone and the Rhœtic beds; 8, the Jurassic formation, including the Lias, the Oolite, and the Purbeck beds, with the Solenhofen slates of Bavaria, and 9, the Cretaceous formation, including the Wealden, the Greensand, and the Chalk.

The CAINOZOIC, or tertiary rocks, consist of the three formations known as: 10, the Eocene; 11, the Miocene, and 12, the Pliocene, and these three last formations are each subdivisible into a lower, or more ancient, and an upper, or more recent, portion. Deposits of the most recent pliocene times are distinguished as *Pleistocene*.

The Eocene rocks in the form of gravels, sands, clays, and limestones, are widely distributed, and vary considerably in thickness. They form the areas which underlie both Paris and London. They constitute deposits known in France as the "Phosphorites de Quercy" and the "Lignites of Soissonais,"* also the Wasatch beds of Mexico, those of Fort Bridges in the south-west corner of Wyoming territory, of Colorado, &c.

The Miocene beds are widely distributed in Europe and North America, but are very slightly represented in England. They include the deposits at White River, Dakota, and the white rivers of Nebraska and Oregon in America, and the deposits of Sansan and Simorre (Gers) in France.† The deposits of Pikermi, in Greece, were thought to be certainly miocene, but it is doubtful now if they are not really of somewhat later date.

The Pliocene formation is an extensive one in Europe, Asia, and the United States, as *e.g.*, between the Rocky Mountains and the Missouri, and Loup River, Nebraska. It may (as just observed) include the reputed miocene beds of Pikermi.

Posterior to the pleistocene deposits are those found in caves and other localities associated with the remains of early man, and known as "*Prehistoric*."

§ 7. Such being the "great groups," the "formations," and the several "strata" in which fossils are found, those of the CAT FAMILY occur as follows:

The genus *Felis* is found in Greece and India, in strata of the

* The "Phosphorites" are *upper* eocene, the "Lignites" are lower eocene.

† The Sansan beds are middle miocene; the White Rivers of Nebraska Oregon, and the John Day region Oregon, are lower miocene.

newer miocene or oldest pliocene age. A cat, the *Felis media* of Larlet, has been found in the middle miocene in France. *F. Christolii* (a cat of the size of the serval) occurs in the lower pliocene of France. In pleistocene times, tiger-like cats, with the leopard, lynx, and wild cat, were found in England.

Felis spelæa became extinct north of the Alps at the close of the pleistocene age; but, as has been said, the well-known "lions" which existed in Macedonia in the time of Xerxes may have been surviving examples of that species.

Machærodus is preserved in pliocene and miocene deposits of Europe, India, and America, both North and South. It survived in England down to late pleistocene times.*

Hoplophoneus is from the White River, Nebraska, or lower miocene.

Pseudælurus has been found in the Phosphorites de Quercy, Loup River, Nebraska, and Sanson (Gers). It is therefore eocene and miocene and pliocene.

Nimravus is a form from the White River, Oregon, and, therefore, of lower miocene times.

Dinictis is eocene and miocene, occurring as it does in the Phosphorites de Quercy and the White Rivers of Colorado, Nebraska, and Oregon.

Archælurus is from the lower miocene beds of the John Day region of Oregon.

Pogonodon is from the same region as *Archælurus*.

Eusmilus is eocene, from the Phosphorites de Quercy, and

Ælurodon is from the pliocene of Loup River, Nebraska.

The forms which are oldest therefore, are *Pseudælurus*, *Dinictis*, and *Eusmilus*. That is to say, the first in time for which we have any evidence are two genera which, in very different degrees, differ from the cat type and approach less specialized forms, and also one genus which is most extremely specialized.

Next come *Pogonodon*, *Archælurus*, *Nimravus*, *Hoplophoneus*, *Machærodus* and *Felis;* that is to say, the most generalized forms of all the *Felidæ*, together with extremely specialized forms.

Nevertheless it is a fact that the genera which most approach ordinary non-feline carnivora—the genera namely *Archælurus* and *Dinictis*—are from the eocene or older miocene, and none of the most generalized forms have as yet been found in pliocene strata.

No feline remains have been discovered in any deposit whatever which is older than the eocene, *i.e.*, there are none in any mesozoic or secondary strata.

§ 8. But very few mammalian remains of any kind have as yet been found in secondary rocks, though of course multitudes of mammals must have existed before the eocene strata were deposited. The remains of beasts first make their appearance in the upper

* See a paper by Professor W. Boyd Dawkins on Tertiary Mammals, Quarterly Journal of the Geological Society, August, 1880.

part of the trias and also in the oolite, including the Purbeck beds. Such remains have been found in both Europe and North America, and consist of the genera *Microlestes* and *Dromatherium*. *Microlestes* is a small insect-eating beast,* of which a few teeth have been discovered. *Dromatherium* † is a small American mammal, the mandible of which bore on each side three incisors separated by short intervals, a canine, and ten teeth in a continuous series of premolars and molars.

Other mesozoic forms are *Amphitherium*, *Amphilestes*, *Phascolotherium*, and *Stereognathus*.

Amphitherium ‡ is a genus founded on a lower jaw, with three incisors and a canine on each side, but with a series of twelve premolars and molars. The angle of the mandible is not inflected in *Amphitherium*.

Amphilestes § is a form similar to the last, but with teeth more bristling with pointed tubercles, suited for crushing the bodies of insects.

Phascolotherium ‖ had three rather separated incisors on each side of its mandible, a canine, and a series of only seven teeth representing the premolars and molars. The angle of the mandible was inflected.

Stereognathus ¶ is an extinct form known by a portion of a mandible (from the Stonesfield slate) three quarters of an inch long, with three teeth quadrate in form, each with three pairs of cusps, and not distinctly resembling those of any existing group of animals. These forms (except the last mentioned) have been generally presumed to be marsupial, from their resemblance to certain modern marsupials, such, *e.g.*, as *Myrmecobius*, a small Australian opossum, with a series of nine molars, a canine, and three rather separated incisors on each side of the mandible. Some of the fossil genera also present certain resemblances in the form of the molar teeth, or in the position of the dental foramen, to American opossums (the genus *Didelphys*) or to kangaroo-rats (*Hypsiprymnus*). The above are the yet known secondary mammalian forms.

When we enter upon eocene strata we come at once upon a multitude of mammalian species now passed away, some of which it will be well here briefly to pass in review for reasons which will appear in the next chapter. Amongst eocene mammalia a group of fossils must first be mentioned which have been associated together by Professor Cope under the term *Creodonta*.** Some of these creatures have

* See Owen's Palæontology, p. 301.

† *L.c.*, p. 302.

‡ See Owen's British Fossil Mammals, p. 29.

§ Owen's Palæontology, p. 303, and Brit. Foss. Mam. p. 58 (*Amphitherium Broderipii*).

‖ Owen's Palæontology, p. 304, and Broderip, Zoological Journal, vol. iii., p. 408, plate 40.

¶ Owen's Palæontology, p. 308.

** See his paper on Creodonta, read before the American Philosophical Society in July, 1880. See also his paper on the Flat-clawed Carnivora of the Eocene of Wyoming, in the Proceedings of the American Philosophical Society, vol. xiii., No. 90, 1873. See also Professor Flower's Extinct Animals of North America, a lecture delivered at the Royal Institution on March 10th, 1876.

claws which, unlike those of cats, dogs, and other existing carnivora, were nearly flat, straight and blunt. In none did the carpus contain a scapholunar bone, but it had two separate bones in its place. The jaws of the Creodonta were long and rather slender, containing a number of molars, all more or less alike, and (in most genera) all sectorial in form, instead of being differentiated into a few simple premolars and one large sectorial tooth, with one or two tubercular teeth behind it—as are the teeth of almost all existing carnivora. The astragalus, moreover, instead of presenting that peculiar pulley-like shape which we have seen in the cat, presents in almost all these creatures a plain flat surface as in the existing Insectivora, Rodentia, Proboscidea, and Apes.

One of these eocene forms has been called *Proviverra*, by Rütimeyer, and Gaudry* has described a similar form (from the Phosphorites de Quercy), which, in many respects, reminds us of Marsupials. The angle of the mandible, however, is not inflected, and the bony palate is well ossified, and there are only six incisors in the upper jaw. The teeth behind the canines (of which there are six or seven in each jaw) are all sectorial, except the last upper one, which is placed transversely. The cerebrum is so little developed that not only the cerebellum but even the corpora quadrigemina are uncovered by it, while the olfactory lobes are largely developed.

Pterodon† is a form very similar to the last, with several sectorial teeth in each jaw. The structure of the feet of this animal is as yet unknown.

Oxyæna‡ is an American mammal, some individuals of which were as large as the jaguar. It is closely related to the European form *Pterodon;* but there are but two superior true molars, and the last of these is driven in transversely. The first true upper molar is the sectorial tooth, instead of the sectorial being the last premolar, as in existing Carnivora. The two last inferior molars are described as "tubercular-sectorial."

Stypolophus is another American mammal, said by Cope§ to differ from *Oxyæna* only in certain details of tooth structure, namely, in having the three last lower molars "tubercular-sectorial."

Mesonyx‖ is very similar to the preceding, and also American. It has seven inferior teeth behind the canines, but "the trochlear face of the astragalus is completely grooved above as in the true Carnivora, and its distal end presents two facets, one for the cuboid and the other for the navicular bones."

* See A. Gaudry's Enchainements du Monde Animal, p. 20, figs. 13–15. This genus is the Cynohyænodon of Filhol.

† Gaudry, *l. c.*, pp. 15–24, figs. 5 and 6; see also Gervais, Paléontologie Française, p. 236, plates 11 and 26, and Filhol, Ann. des Sc. Geol., vol. vii., p. 218, figs. 184–188.

‡ See Cope's paper on Creodonta, read before the American Philosophical Society in July, 1880, p. 2.

§ Cope, *l. c.*, p. 3.

‖ Cope, *l. c.*, p. 2; and see also his paper on the Flat-clawed Carnivora of the Eocene of Wyoming, in Pro. of the Amer. Phil. Soc., vol. xiii., No. 90, 1873. Professor Cope believes that Synoplotherium is really a species of Mesonyx.

In *Miacis** on the other hand, the astragalus is flat, but in the lower jaw "we have a near approach to the dentition of the dogs."

Didymictis,‡ from the American lower eocene, is closely allied to *Miacis*, differing only in having one less inferior tubercular molar.

Palæonictis † is a genus which is thought to resemble the Viverrine Carnivora in its teeth, save that the second lower true molar is rather sectorial unlike that of existing carnivorous mammals.

Amblyctonus § seems only to differ from the last in that its fourth inferior premolar supports tubercles instead of a cutting edge.

Patriofelis ‖ is a genus founded on some fragments of a jaw obtained by Professor Hayden from near Fire Bridge, Wyoming. It was larger than the panther, the lower jaw being six inches long. It has similar characters to those of Mesonyx, save that there are only five lower molars instead of seven.

Hyænodon¶ is a well-known European form, but is found in America also. It has also sectorial molars in large number, but its brain** was formed on the same type as that of the existing carnivora. *Hyænodon* has a scapho-lunar bone.

Arctocyon, the oldest mammal yet discovered posterior to the mesozoic epoch, is another long and well-known European fossil†† animal of the lower eocene. It is almost as large as a wolf, with a long tail and a much curved humerus with a strong deltoid ridge. The skull is very narrow between the middle of the zygomatic arches, and has large palatine foramina. The brain had large olfactory lobes and a small cerebrum which left the cerebellum and probably the corpora quadrigemina uncovered and was almost unconvoluted. There were seven upper molars. The first of these had one root, the second and third two roots, then came a triangular tooth (slightly sectorial in character), followed by three tubercular molars, the last but one being the largest. The teeth were generally tubercular. The ankle joint is unknown.

Cynodon ‡‡ is an upper eocene form, considered by M. Gaudry as intermediate between the dogs and civets, some species being more like one and others more like the other of these two types. Like

* Cope's paper on Creodonta, pp. 3 and 58.

† Cope, *l. c.*, p. 3.

‡ Cope, *l. c.*, pp. 3 and 6. See also Gaudry, *l. c.*, p. 19, fig. 11; and Gervais, Paléontol. Française, p. 225, plate 25, figs. 11, 12.

§ Cope, *l. c.*, p. 3.

‖ See United States Geological Survey of Territories, vol. i., p. 114, plate 7, fig. 20; and Pro. Acad. Nat. Sc. Philadel., March, 1870, p. 11, plate 2, fig. 10.

¶ See Gaudry, *l. c.*, p. 14, figs. 3 and 4; also Gervais, Pal. Franç., p. 232, plate 24; Filhol, Ann. des Sc. Geol., vol. 7, p. 162; and Leidy's Mammals of Dakota and Nebraska, Journal Acad. Philadel. vii., p. 39, plate 2; and De Blainville's Ostéog. (*Canis*), p. 17; and De Laizer and De Parien, Ann. des Sc. Nat., 2nd series, vol. xi., 1832.

** Nouvelles Ann. du Muséum, 1870, plate 6, fig. 7.

†† De Blainville (Subursus), p. 73, plate 13; Gervais, Paléontol. Franç. p. 220; and Nouvelles Ann. du Mus., vol. vi., p. 147, plate 6, fig. 4 (brain); Gaudry, *l. c.*, pp. 22–24, fig. 14.

‡‡ See Gervais, Paléontol. Fran., p. 218, plate 15; and Aymard, Ann. de la Soc. Acad. du Puy, vol. xv., p. 92, 1851; also Gaudry, *l. c.*, p. 215, figs. 282 and 283. M. Filhol has shown the great variability of Cynodon.

Arctocyon it has seven molar teeth in the upper jaw, the three hindmost being tubercular. The tooth next in front of these three is, however, of a more sectorial character than in the corresponding tooth of *Arctocyon*.

Cynodictis * is another upper eocene carnivore which closely resembles Cynodon, but there are only two tubercular teeth behind the upper sectorial.

Amongst the forms of life of the uppermost eocene and lower miocene may be mentioned *Amphicyon*,† which is another well-known fossil form allied to the dogs, from which it differs in that its molars are less sectorial and more tubercular, and that it has a third upper true molar. Its limbs are more bear-like than are those of the dogs, and it was also plantigrade.

Hyænarctos ‡ is a widely distributed form from the upper miocene, which has marked affinities with that just noticed; but its tubercular teeth are still larger, and specimens of most recent date (from the pliocene beds of Montpellier) have the tubercular teeth more quadrangular in form and therefore still further removed from the sectorial type, approaching more and more to the structure we now find in the bears.

Ictitherium § is a genus of which various species have been described; some as large as a leopard. They are found in the upper miocene or pliocene of Europe. It is intermediate in its dental structure between the civets and the hyænas, in that it has a second upper tubercular molar. This tooth is different in size in different species of the genus, being very small in *I. hipparionum*.

Lutrictis ‖ is a miocene form from Auvergne which belongs to the family of *Mustelidæ*, but has a minute second upper molar. M. Gaudry considers it allied to the otter.

Galecynus ¶ is a miocene and pliocene form which is very fox-like, but has the first premolar smaller, and the third and fourth larger, and all the teeth are more close-set and occupy a smaller space than in the fox. The bones of the feet also are more robust.

As to non-carnivorous mammals, it is evident that bats and opossums (*Didelphys*), tapirs and rodents existed in Europe in eocene times, while with the miocene period, apes, rhinoceroses, giraffes, and hippopotami co-existed in our continent. Many other forms might also be enumerated, but the above list may be sufficient for our present purpose, as affording examples of eocene and miocene mammals which present more or less interesting,

* Gervais, Paléontol. Franç., p. 216; Filhol's Ann. des Sc. Geol., 1876, vol. vii., p. 66.

† Gervais, Pal. Franç., p. 214, plate 28; Filhol, Ann. des Sc. Geol., vol. vii., p. 55, figs. 23–26, and 41–43; Leddy, Mammals of Nebraska and Dakota, Jour. of Acad. of Nat. Sc. Philadel. vii., p. 31, plates 1 and 5; Gaudry, *l. c.*, pp. 24 and 212, fig. 277.

‡ Gervais, Paléon. Franç., p. 207, plate 81; Gaudry, *l. c.*, pp. 212, 213, figs. 278 and 279.

§ Gaudry, *l. c.*, pp. 208, 216, and 217, and figs. 274, 284, and 286. See also his Fossils of Pikerni, p. 52, plates 7, 12.

‖ Gaudry, *l. c.*, p. 219, fig. 290.

¶ Owen, Quarterly Journal of Geol. Soc., vol. iii., 1847, p. 55.

more or less significant structural relations with the anatomy of the cat—mammals to which reference will have to be made in the following chapter.

§ 9. The next and last point to be considered in studying the cat's hexicology, concerns its RELATIONS WITH OTHER LIVING BEINGS.

Living beings may affect each other's existence in a variety of ways, as food, as rivals, as indirect friends, or as direct enemies.

Now, in the first place, the *Felidæ*, as essentially carnivorous animals, can only live where they can find such other animals as may be necessary for their food; and, accordingly, it is where land animals are most abundant, that the most numerous and largest kinds of the cat family are found. Certain kinds of cats also are, as we have seen, of arboreal habits; and the presence or absence of forests will very importantly affect the existence here or there of such forms.

The markings of cats have been supposed to be useful to them in various ways in their relations with other animals. The vertical stripes of the tiger resemble the vertical shadows of the grasses of the jungle amongst which it lurks, and may so aid its concealment and allow its prey to approach it unsuspectingly and fatally. The scattered spots of the leopard agree with the scattered spots of shadow amongst the foliage of the trees on the boughs of which it lies in wait. Similarly the hue of the lion has been thought to be useful to it in sandy plains. All this is no doubt true, but a multitude of instances are to be found in nature in which shapes, colours, and markings are most noticeable, but yet do not answer any purpose of the kind above referred to, and therefore to regard such relations as the main causes by which these markings have been brought about would be to rest in an explanation fundamentally inadequate.

Animals stand to each other in the relation of *rivalry* where they each consume the same kind of food and thus tend to starve each other. Such a rivalry must evidently exist between different kinds of cats, and so prevent the coexistence of many kinds or many individuals of the same kind in the same locality.

Living creatures may unintentionally act a friendly part to one another; inasmuch as animals of one kind may destroy creatures which are inimical to the existence of another kind, and thus every animal which destroys creatures which prey upon feline animals of course benefits the latter. Again, whatever creature tends to render abundant the food of another creature is of course the latter's benefactor. Thus it has been observed that the presence of a certain kind of clover is beneficial to cats; inasmuch as it is useful to a particular species of humble bee, the nests of which favour the existence of mice, which again are the food of cats. Did we know the analogous inter-relations which exist between the living creatures of tropical forests, we should doubtless come upon many curious correlations and interdependencies of a similar kind, affecting the feline population.

But various kinds of cats seem to have other cats for their dir-

mies; for we have seen that the tiger will even carry off and our a wounded individual of its own species.

The direct enemies of the largest and most powerful cats must be ; since the great beasts which may successfully contend with n—elephants, rhinoceroses, &c.—being herbivorous creatures, not impelled by hunger to pursue and attack them. The smaller no doubt occasionally fall a prey to other carnivora, but who- r has seen a dog attack a cat, and has noted the combined ferocity dexterity which the cat can exhibit with its very efficiently armed rs, may well doubt whether wild-cats of any kind will often be cessfully attacked by any creatures not overwhelmingly superior hem in size and strength.

10. Against other enemies, however, of a very different kind, even largest cats have no power of resistance. Such enemies are their rnal and external PARASITES. These chiefly belong to the sub- gdom *Vermes*. The first group is that of the thread-worms *matoidea*). Of these there are several species which find a home the body of the cat. They are* *Ascaris mystax*, *Trichina spiralis*, *chosoma cati*, *Oxyuris compar*, *Strongylus tubæformis*, and *Olulanus uspis*. The second group is that of the flukes (*Trematoda*), of which re are not less than three kinds, namely, *Distoma lanceolatum*, *Am- stoma truncatum*, and *Hemistoma cordatum*. The third group, t of the tape-worms (*Teniada*), is represented by at least eight cies as follows:—*Tænia elliptica*, *Tænia crassicollis*, *Tænia iteres* (Baird), *Tænia litterata* (*Tænia canis-lagopodis*), *Tænia ata*, *Bothriocephalus felis*, and *Bothriocephalus decipiens*. The *ticercus cellulosæ*, or larva of *Tænia solium*, has been obtained n beneath the scapula, and Engelmayer found a *Cœnurus* in a s liver

Dr Spencer Cobbold has observed,† "Every owner of cats must e, from time to time, noticed the frequent occurrence of sickness ongst these animals; such fits of vomiting usually terminating in expulsion of worms from the mouth. The internal parasites sing these attacks are small nematodes (*Ascaris mystax*) occupy- the stomach; the females being nearly twice as long as the es, and sometimes measuring as much as four inches. *Strongylus æformis* is occasionally found in the upper intestine, and *Trichina alis* has been reared in the cat by experiment. . . . . The most portant of all the feline nematodes is a little worm, *Olulanus uspis*. Whilst the full-grown *Olulanus* only measures about $\frac{1}{2\cdot5}$ n inch, its embryos are, for so small a creature, of almost gigantic . The adult worm resides in the lining membrane of the stomach. young of this parasite, like young *Trichinæ*, are apt to migrate within body of the feline host. They thus become encysted within the gs and liver; but not in any other of the visceral organs. I have

* For the list here given I am indebted e kindness of my friend Dr. T. Spencer bold, F.R.S.

† See his work on The Internal Parasites of our Domesticated Animals, p. 124; and his more recent work on Parasites, p. 308.

seen tens of thousands of them occupying the lungs; the infest animal perishing in consequence of the inflammatory action set by their presence."

"A certain number of the embryos of *Olulanus* escape by the bow of the host. These when swallowed by mice become encysted with the little rodents' muscles, very much after the fashion of *Trichin* So that one may say the mice become olulanised in the same w that we say people or animals become trichinised. All this has be experimentally proved by Leuckart, who fed a cat with olulanis mouse-flesh, and afterwards found the escaped young in the ca alimentary canal. As, however, these encapsuled *Olulani* from t mouse had not become sufficiently advanced in their larval * organ sation, Leuckart did not succeed in rearing the sexually matu parasite in the feline stomach. But there could be no doubt as to t ultimate destiny of the encapsuled young. . . . . *Tænia crassicoll* which is common to both the tame and wild animal, is obtained b the cat from eating the livers of rats and mice, in which organ th larvæ of the parasite reside. *Tænia lineata* is found only in the wi cat. *Bothriocephalus decipiens* is extremely rare, and only known i the house cat. The most common of all the species is *Tæn elliptica*." *Tænia litterata* exists in Iceland, but has also been foun to infest the cheetah. It must therefore have a wide distribution.

One of the most remarkable instances of the destruction of ca by internal parasites is that recorded by Dr. Romano, of Gemon The animals perished from colic, diarrhœa, epileptiform convulsion wasting, and complete prostration. All these symptoms result from tapeworms (*Tænia crassicollis*) within the stomach. The ou break occurred at Osoppo, where the fortress was over-run by ra The vermin were combated by means of the cats, and thus the m successful felines became the earliest victims. Those which killed rats and ate their livers swallowed the larvæ of the *Tænia*, wh latter, *en revanche*, brought about the destruction of their feline hos

Another internal parasite is the worm-like animal *Pentast denticulatum*, which is a very aberrant member of the cl *Arachnida*.

As to the cat's external parasites, they belong to two orders the class Insecta (the order *Aphaniptera*, which contains the fl and the order *Aptera*, which is the order to which lice belon and to the class *Arachnida*.

The cat's flea,‡ *Pulex cati*, is very like the flea of the dog, but one-fourth smaller.

The louse-like animal of the cat does not belong to the sa

* The tape-worms have two stages of existence, corresponding with the grub (or larval) condition, and the perfect (or imago) state of the beetle or butterfly.

† See Cobbold's account (Parasites, *l. c.*), abridged from Romano's report in Giornale di med. vet. pratica for August, 1877.

‡ See a paper by Dr. Alexander boulbène, on Les Metamorphoses d Puce du Chat, in the Annales de la Entomologique de France, 5th se vol. ii., 1872, p. 267, plate 13; P. Megnin's Parasites, Masson, P 1880, 63.

ıily of the order as that which contains the lice of men and apes. ɔelongs to the family which contains the bird-lice. This parasite he cat is called *Trichodectes subrostratus.** Its presence appears ɛause no evil or inconvenience to its host.

The arachnidan external parasite is a sort of itch insect, named ·*coptes cati.*† It is so small as hardly to be visible to the naked , but soon accumulates in vast numbers (to the cat's extreme ıoyance), especially on the head, ears, eyelids, and face, where it ses swellings as well as baldness, beginning on the back of the k and head. The paws, also, are apt to be affected, as naturally ues from the infected animal's vain attempts to remove the se of distress. Catarrh, diarrhœa, distemper, consumption, and ınity, are amongst the disorders from which cats are more or ı apt to suffer.

* See Megnin's Parasites, p. 81; also Piaget's fine work, Les Pédiculines,), p. 389, plate 31, fig. 9; and Henry ıy's Monographia Anoplororum Britanniæ, 1842, p. 189.

† See P. Megnin's Parasites, pp. 174 and 409.

CHAPTER XV.

THE PEDIGREE AND ORIGIN OF THE CAT.

§ 1. In the preceding chapters, the creature which has been selected as a type of mammalian back-boned animals, has been represented from various points of view. Its anatomy, physiology, psychology, taxonomy, and hexicology, have been successively treated of and the processes of *individual development*—the series of changes gone through by each individual of the cat species in reaching maturity—have been noticed. It only now remains to study the *development of the species*—that is to say, the "pedigree and origin," both of the cat considered as a species, and of the whole family of *Felidæ*.

To trace, as far as may be, the series of forms through which the existing group of cats may, with most reason, be believed to be descended, is, in this sense, to trace the cat's PEDIGREE. To investigate the probable causes which have evolved such forms and governed such process of development, is to investigate the cat's ORIGIN.

§ 2. That the various kinds of cats, and the whole cat group, have been evolved through the orderly operation of powers divinely implanted in the material creation, is a statement the truth of which can now, it seems, be hardly denied by any consistent persons who are not prepared to maintain that with the birth of every very exceptionally formed kitten a direct intervention of the First Cause takes place—an intervention such as does not otherwise occur in orderly sequence of purely natural phenomena.

§ 3. In order to investigate the question of the cat's pedigree, or *phylogeny*, its relation to other animals must be carefully borne in mind.

In the thirteenth chapter it was pointed out that the cats are most nearly related to the Foussa (*Cryptoprocta*), and in a less degree to the other members of the family *Viverridæ*. That they have a more general affinity to the whole sub-order *Æluroidea*, and a still more general one to the whole order *Carnivora*, and ultimately to mammals and to all backboned animals—beyond which they can be said to have no special affinities at all

The ancestors then of the cat family must be sought for amongst

ict forms of carnivora nearly related to the cats and civets; and ancestors of such forms, again, must be sought amongst carrous mammals of more and more generalized structure till we to creatures from which all mammals may be supposed to have nded. What animals were the progenitors of all mammals, is t a matter of pure speculation, and no positive judgment can be ed concerning it by any prudent naturalist. Certain probaes, however, are evident as to this and cognate questions, but e adverting to these probabilities, it will be well to recall to some of those existing and extinct animals to which reference lready been made.

ie most aberrant and generalised of all existing cats is the tah (*Cynælurus*). But though this animal approaches the other vora in that its claws are less retractile than those of other cats, ts tooth structure—its upper sectorial *—is exceptional in a way liarly its own. Neither *Cynælurus*, therefore, nor its extinct *Ælurodon*, seems to help us towards tracing the cat's pedigree. ie flat-headed cat (*F planiceps*), as has been shown (Fig. 177), oximates somewhat towards viverrine forms in the large size of vo-rooted first upper molar. But the extinct genera *Pseudælurus*, *tis*, and above all, *Archælurus*, lead us decidedly towards more ralized forms, and render the descent of both *Cryptoprocta* and from some common Viverrine root a matter highly probable.

must be borne in mind, however, that although these miocene eocene cats were thus generalized in structure, yet a most exely specialized form of cat, *e.g.*, *Eusmilus*, existed at the same period. But a very generalized kind of dog, *Otocyon* (which has premolars and three molars on either side of each jaw), exists y side by side with dogs in which the number of teeth is much and which are more specialized. Yet naturalists do not on that nt doubt but that *Otocyon* is a survivor of an earlier condition common to the whole group of *Cynoidea*. Similarly the coence of *Eusmilus* with *Dinictis* or *Archælurus*, does not detract the probability that in the last two genera we have examples of ort of animals whence all cats come.

ological and palæontological evidence, then, points to a viverrine n of cats. They seem either to be the very specialised descendof ancient viverrine animals, or else both cats and viverrines are diverging descendants of an ancient, more generalized form h existed in times anterior to the eocene, of which more geneed form no relics have as yet been discovered.

4. But the viverrine animals themselves, whence came they? he existing creation, they are distinguished from the hyænas by ng two upper tubercular molars. But Professor Gaudry has overed a form (named by him *Ictitherium hipparionum*, which, e have seen,† is intermediate between the civets and hyænas,

* See *ante*, p. 428.

† See *ante*, p. 507.

and which, though it has two upper tubercular molars, has the hinder one quite rudimentary.*

The civets, again, differ from the hyænas, in having a lower tubercular molar. But the same accomplished palæontologist has discovered another fossil form, *Hyænictis*,† which is hyæna-like, but yet has a rudimentary lower tubercular molar tooth.

But can we get any probable suggestion as to the origin of the cat's sub-order, the *Æluroidea?* To be able at all to answer this question, we must glance at fossil forms related to the other carnivorous sub-orders. As regards the dogs (*Cynoidea*), the existing *Otocyon*, and the fossil genus *Galecynus*,‡ lead down to forms of more general affinities which may have been dog ancestors. One such is *Cynodictis* § (of the upper eocene), and which leads on to *Cynodon*,‖ which is a still more generalized form, showing, in M. Gaudry's opinion, certain affinities to the civets.

Amongst the *Arctoidea*, the weasel family (*Mustelidæ*) is—inasmuch as it is an arctoid family—distinguished by a variety of characters¶ from the *Viverridæ*. Amongst the characters by which it differs is that of the absence of a second upper tubercular molar. In *Lutrictis*,** however, we have a musteline form in which the second upper tubercular molar is present, though very small.†† In *Proælurus*,‡‡ also, we have a fossil with seeming musteline and viverrine affinities, yet with teeth which approximate to those of the cats. The true bears (*Ursidæ*) were preceded by mammals such as the miocene *Hyænarctos*,§§ which, with the help of *Amphicyon*,‖‖ apparently connects them with the dogs.

The three sub-orders of carnivora being thus brought near together in the past, to what other group can they—*i.e.*, can the whole order Carnivora—be affiliated? What may probably have been the cat's ancestors in a yet more remote degree than the unknown common stock whence the three existing suborders gradually diverged?

§ 5. We have seen¶¶ that the oldest tertiary mammal *Arctocyon*, has characters which give it some claim to be nearly allied to the progenitor of all true carnivora. But besides such characters, we find in it conspicuous defects of palatal ossification, and a low form of brain, which characters would seem to make it impossible that its claim to be an ancestor of the carnivora should be established. Moreover, we have seen that there are a number of eocene fossils such as *Pterodon*, *Proviverra*, *Hyænodon*, *Palæonyctis*, &c.,*** which agree in having (amongst other common characters) teeth which are not differentiated into premolars and an upper and lower sectorial

* See Les Enchainements, p. 217, fig. 286.

† *L. c.*, p. 218, fig. 289.

‡ See *ante*, p. 507.

§ See *ante*, p. 50.

‖ See Les Enchainements, p. 215, figs. 282 and 283.

¶ *Ante*, p. 475.

** See *ante*, p. 507.

†† See Les Enchainements, p. 219, fig. 290.

‡‡ See *ante*, p. 435.

§§ See *ante*, p. 507, and Les Enchainements, pp. 212 and 213, figs. 278 and 279.

‖‖ See *ante*, p. 507, and Les Enchainements, p. 212, fig. 277.

¶¶ See *ante*, p. 506.

*** See *ante*, p. 505.

tooth followed by one or more tubercular molars, but which, instead of this, had a series of sectorial teeth.

§ 6 It has been contended by several eminent palæontologists that these creatures were marsupial, and that all the first mammals were didelphous mammals—an opinion supported by the before explained* resemblance of the mesozoic mammalian fossils to the existing marsupial—*Myrmecobius*.

If this view is correct, the pedigree of the cat descends through marsupial ancestors to the most generalized placental (or monodelphous) carnivora. It is here contended, however, that such was not the case, but, on the contrary, that it is probable that the cat never had a marsupial (or didelphous) ancestor at all, but that its progenitors (anterior to carnivores) were long-lost beasts of the Order *Insectivora*. It appears indeed to be probable that Insectivores and not Marsupials were the parent forms of the great Mammalian stock—*i.e.*, that the hedgehog and not the opossum is the existing representative of the root-form of that class to which we (as animals) and the cat both belong.

Those characters in which *Pterodon*, *Proviverra*, *Hyænodon*, *Palæonictis*, &c., have been thought to resemble marsupials, tell equally in favour of their affinity to the Insectivora. Such are the small brain, with uncovered corpora quadrigemina and large olfactory lobes —characters which has been shown to have existed in *Proviverra*† and *Arctocyon*.‡ Such again are the numerous sectorial teeth of *Hyænodon*, *Pterodon*, *Palæonictis*, *Proviverra* and others, and the defective palatal ossification of *Arctocyon*. Moreover these forms do not possess more than six incisors above and below, while the angle of the mandible is not inflected. If the angle were inflected, however, such a character would not be decisive in favour of their marsupial affinities, as the Taurec (*Centetes*), though a placental mammal—a member, moreover, of the order Insectivora—has its mandibular angle inflected. *Hyænodon* and *Pterodon* have also been shown § to have possessed a complete milk dentition, a character which separates them markedly from all existing marsupials.

To this reasoning it may be replied, that true marsupials existed in Europe contemporaneously with the beasts the nature of which is in dispute, and that the earliest known mammalian remains (those of the secondary rocks) resemble existing marsupials. These assertions are true, but in the first place the existence of marsupials, with such creatures as *Proviverra*, only proves that marsupial life was then already developed as well as placental life, a fact of which we have abundant evidence.‖ Such a fact, however, in no way shows that the latter was derived from the former. Then as to the mesozoic mammals, the forms now living which they resemble, *i.e.*, *Myrmecobius*, is just one of those marsupials to which

* See *ante*, p. 504.

† See Les Enchaînements, p. 21, fig. 15.

‡ See P. Gervais, in Nouv. Archiv. du Muséum, vol. vi., *1870*, p. 147, plate 6, fig. 4.

§ By M. Filhol, see Ann. des Sc. Géologiques, vol. vii., p. 169, plate 22, fig. 79, and plate 31, fig. 148, 1876.

‖ See *ante*, p. 507.

the specially marsupial character, "the pouch," is wanting. The same is the case in the allied genus *Phascogale*, while in most of the small American opossums (*Didelphys*), the pouch is not developed. The character is still a very variable one in many forms of the order—as if it had not become even now a well-established character. In the predatory opossum—the so-called Tasmanian wolf (*Thylacinus*)—"the marsupial structure, if shown at all, is represented by a pair of shallow, semi-lunar fossæ, with their concave outlets opposite each other as in *Echidna*." *

It is the very highly specialized Australian kangaroos and phalangers—forms which may be relatively modern developments—which have the pouch most completely formed and which may be considered the typical representatives of marsupial life.

Moreover the secondary fossils, *Amphithorium*, *Amphilestes*, *Dromatherium* and *Phascolotherium*, had, as we have seen,† but six incisors in the mandible, while only in *Phascolotherium* was the mandibular angle inflected. All then that the yet discovered mesozoic fossils can be held to demonstrate is, that there existed at the time of their entombment, forms having both placental and didelphous affinities and which may have been some of the as yet undifferentiated ancestors whence those two now divergent subclasses of mammals have descended.

And it is far from impossible that some existing marsupials may have come from a different root from that which gave rise to others. Forms may have grown alike from different origins, as few things are more certain in the matter of development, than that similar structures often arise independently, and causes which would induce marsupial modifications in the descendants of one root-form might well also induce them in those of another root-form. The singular difference in the structure of the hind-paw in the more typical marsupials—the kangaroos and phalangers—from that which is found in *Didelphys*, *Dasyurus*, *Phascogale* and *Myrmecobius*, seem to point to a two-fold origin of the modern order *Marsupialia*. The hypothesis that which represents the most ancient mammals to have been allied to the Insectivora, is one which appears to me best to accord with the facts yet known. Thus we may account for the low brain-structure and defective palate of *Arctocyon*; for the form of the molars of *Proviverra* and its allies; for the form of the astragalus noted by Professor Cope; for the number of the inferior incisors, for the rare inflection of the mandibular angle and for the existence of a complete milk dentition.

From this Insectivorous root then, the Marsupials, as we at present know them, must have diverged as a relatively unimportant branch, while the main stem of the mammalian tree was continued on by the successively arising placental forms of life. It seems far more likely that the allantois came to atrophy and the pouch to be developed, and that so the modern marsupial structure was initiated;

* So says Professor Owen, Philosophical Transactions, 1865, p. 676.

† See *ante*, p. 504.

that the allantois should first appear as a functionless rudi-
. It also seems more probable that the habit of forming milk
is one which has been lost or almost lost in certain mammals,
that the process should first have arisen through the replace-
of a single, relatively unimportant, tooth, by a vertical successor
—a condition which has been found* to be the case in the
ıpials of our own day.

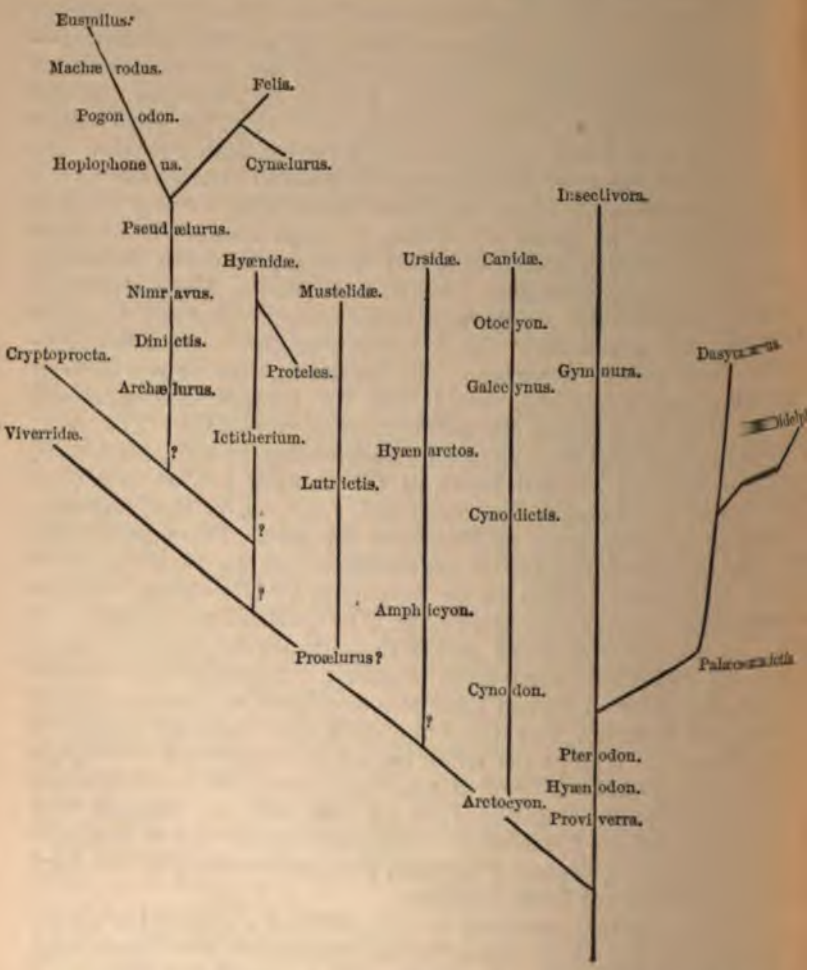
. The succession of mammalian carnivorous life—the mammalian
n of the CAT'S PEDIGREE—may then be represented as follows :—
ɔm unknown Insectivora-like mammals, two diverging series of
may have started, one soon leading to *Arctocyon* (as the
tivora-like root of the placental Carnivora), the other series
ɔping such forms as *Proviverra*, *Hyænodon*, and *Pterodon*, and
ıuing on the main stem through Gymnura-like creatures to the
ru *Insectivora*. From this insectivorous stem we may imagine
-shoot to be given off leading through *Palæonictis* to forms
ertain existing marsupials, and diverging into the American
ohys and the analogous Australian *Dasyurus*. From *Arctocyon*
ay conceive the great carnivorous branch—destined to quite
ss and overshadow the insectivorous stem—to divide into
l and arctoid branches. The former continuing on through
lon and *Cynodictis*, would lead up through *Galecynus* and
like the existing *Otocyon* to the typical *Canidæ*. The great
d branch may have given off a limb leading through *Amphicyon*,
arctos and kindred forms, to the existing *Ursidæ*, and then
ıued on through *Proœlurus* and *Lutrictis*, as the *Mustelidæ*.
some such form as *Proœlurus* the great Æluroid sub-order
ıave started, and before continuing on, as the *Viverridæ*, have
off a great branch to be developed, by bifurcating, into the
idæ, *Cryptoproctidæ* and *Felidæ*. The first family is the culmina-
of one division which passes through *Ictitherium*, and which
off *Proteles* as a one-sided branchlet. The other division into
the Æluroid branch bifurcates, continues on as the cats, first
off however, near the bifurcation, the branchlet ending in
oprocta. The proper feline branch then continues on through
elurus, *Dinictis*, *Nimravus* and *Pseudælurus*, and then bifurcates.
ls in the typical genus *Felis* on one side—an aberrant twig
given off for *Cynœlurus*—while on the other side it continues
ough *Hoplophoneus*, *Pogonodon* and *Machærodus* † to the very
lized aberrant form *Eusmilus*.

s hypothetical genealogy is only offered as a speculation, especi-
ıat part of it which represents conditions anterior to the evolution
viverrine branch. It reposes mainly upon dental characters,
eth are organs which not only might be expected to vary with

Professor Flower. See his paper Philosophical Transactions, vol. 867, p. 631.

e small lamina of bone which em- the external carotid and so forms the "ali-sphenoid canal" may well have independently disappeared and again, by reversion, reappeared in either sub-division of the feline branch.

varying conditions of life, but which we know to be sometimes very differently formed in different members of one and the same family. Yet we must accept their evidence or none. It is the only evidence which is largely available, nor will there be much danger of serious error in making use of it, if the caution here offered as to its defective nature be duly borne in mind.



§ 8. If we can only conjecture with more or less probability what were the older mammalian ancestors of the cat, we are still less able to determine the line of its descent through non-mammalian ancestors. The structure of the shoulder girdle of the Monotremes, may be held to point towards a reptilian origin of the Mammalia; but the position of the ankle-joint and the constant development in

every species of two occipital condyles rather indicate a Batrachian ancestry. On the whole it seems probable that the Mammalia, and therefore the Cat, descended from some highly-developed, somewhat Reptile-like, Batrachian, of which no trace has yet been found. The yet more remote ancestor of such Batrachian will have to be sought amongst extinct and unknown fishes, intermediate between Ganoids and Elasmobranchs, but with considerable fundamental affinity to the Rays, however different from them they may have been in external aspect. Beyond this point no suggestion worth making can be offered. The genetic relations of the Tunicates and the Vertebrates, or between either of these and any worms intermediate between Tunicates and Vertebrates, which may have existed, cannot be spoken of as even probably known.

§ 9. The foregoing suggestions are offered as results which seem to present themselves to the inquirer into the past history of animal life, and into the cat's *pedigree*.

The next question refers to the cat's ORIGIN. This second question refers, as before said, to the probable causes which have determined that process of evolution which has, in fact, taken place. It is a question of causation: It investigates the "how" and the "why" of the origin of the cat's species, and—as we cannot suppose that the cat is different in this respect from other animals—the cause of the origin of species generally. Evidently that cause must lie either within or without the living organisms which are evolved, unless it be partly within them and partly external to them.

We may conceive the evolution of new specific forms to have been brought about in one or other of the six following ways. The change may have been due:—

(1) Entirely to the action of surrounding agencies upon organisms which have merely a passive capacity for being indefinitely varied in all directions, but which have no positive inherent tendencies to change or vary, whether definitely or indefinitely;

(2) Entirely to innate tendencies in each organism to change in certain directions;

(3) Partly to innate tendencies to vary indefinitely in all directions, and partly to limiting tendencies of surrounding conditions, which check variations except in such directions as may happen to be accidentally favourable to the organisms which vary;

(4) Partly to innate tendencies to vary indefinitely in all directions, and partly to external influences which not only limit but actively stimulate and promote variation;

(5) Partly to tendencies, inherent in organisms, to change definitely in certain directions, and partly to external influences acting only by restriction and limitation on variation;

(6) Partly to innate tendencies to change definitely in certain

directions, and partly to external influences which, in some respects act restrictively, and in other respects act as a stimulus to transformation.

The writer has elsewhere* stated at length his reasons for concluding that the genesis of new species is due mainly to an internal cause, which may be stimulated and aided, or may be more or less restricted, by the action of surrounding conditions.

The notion that the origin of species is due to "Natural Selection" is a crude and inadequate conception which has been welcomed by many persons on account of its apparent simplicity, and has been eagerly accepted by others on account of its supposed fatal effects on a belief in Divine creation.

Its anti-theological character has been declared by a conspicuous English advocate, to be "one of its greatest merits," while it has been made use of as a fundamental dogma in the various polemical works of Professor Haeckel.

The present author's views as to "Natural Selection" having been already fully expressed in former works, it is not thought necessary that further space should here be occupied by their repetition.

§ 10. Before entering upon the question of "Origin," a few words of preliminary explanation seem to be needed. Obviously before we can enter profitably upon the discussion of any proposition, we must clearly understand its terms, and it would be a useless task to discuss the origin of anything as to the existence of which we may have reason to doubt.

Before enquiring into the origin of species, it will be well to make sure what we mean by a "species," and that there really is any such thing.

We have to consider the origin of the cat, as a "species" of the genus *Felis*, of the family *Felidæ*. What then is a "species," what a "genus," and what a "family?" Who has ever seen or handled one of these entities? Individual cats and cat-like creatures of various kinds abound, but no one pretends to have anywhere met with a "family" or a "genus." Why then should a "species" be spoken of as if it had more reality in it than they? In fact it has just as much and no more reality than they have. A "species," like a "genus," or a "family," or an "order," or a "class," is IDEA; and its existence, *as a species*, is only ideal.

Has it then no reality whatever? Undoubtedly it has. A *species* is real, inasmuch as any individual animals actually have in them concrete those very characters and powers which exist abstractedly in the idea of the species. It is just the same with every "genus," "family," "order," and "class." Each and all of these are "real" inasmuch as the abstract ideas they may severally refer to, are concretely embodied in numerically separate and distinct, individual material, living creatures.

* See the "Genesis of Species," and also Chapters VIII., IX., X., and XIV. "Lessons from Nature."

To seek, then, the genesis of species, *as species*, would be to investigate the origin of certain ideas. But that would not be at all the object here pursued. That object is to enquire how it is that a certain concrete entity (a certain animal, which is the living embodiment of one idea) gives rise to another concrete entity—which is the living embodiment of a different idea.

§ 11. Now all our knowledge being derived from experience, we can only (revelation apart) judge of things as they have been, by things as they are; and as every animal is now the product of a parent organism more or less like it, so the natural inference with regard to any antecedent animal, is that it also was the product of a parent organism more or less like it.

But it may be said: "this analogy does not apply to the embodiment of a new species, because" (it may be asserted) "we never see the origin of such an embodiment—we never see anything like a change of species: we cannot, therefore, from our present experience, even guess what may have been the mode of appearance of a concrete entity embodying an idea different from that embodied by the entity which preceded it."

This assertion, however, is here denied, while it is on the contrary affirmed that we *do* see—as far as human eye ever can see or ever could have seen—the origin of concrete embodiments of ideas which are not only as distinct as one species from another, but as distinct as genera, families, orders, classes, and even kingdoms, one from another. It is also here contended that we may see this daily, even in the case of the cat.

It was this consideration—an anticipation of the argument here to be advanced—which caused the facts, and the significance of the facts, of the cat's embryonic development to have been so dwelt upon, as they have been in the tenth chapter of this book. For the incipient embryo of the cat, is no cat: it is not even an animal. Its existence is merely vegetal, and the successive ideas which it embodies (in the course of its evolution) approximate only by degrees to that embodied by the adult animal. The embryo which is to become a cat, successively embodies ideas which are analogous to, though they are never identical with, those which are manifested in rhizopods, sponges, worms, fishes, batrachians and other inferior animal natures. We see these changes as facts; the actual "how," the ultimate mode in which the living idea or form is embodied in and identified with the matter it informs, is one of those impenetrable secrets of nature for ever closed to human ken, as the mode in which—the actual "how"—the mind is enabled to know itself and things external to it, is closed to human ken. None the less, everyone who admits that the living cat when adult is informed by a psychical principle of individuation, may be called upon also to admit that its developing embryo is successively informed by psychical principles of individuation of different orders—orders which present no trifling analogy to different orders of animals which exist permanently. After the true cat form has been once attained, such changes

cease, and, till death, the cat remains a cat simply. With death, however, the process of change recommences (though it is a very different process), and continues during the gradual recession of all those forms which have any relation to life, till the body is reduced to mere inorganic matter.

§ 12. According to our present experience then, we ought to anticipate that any new ideal embodiment—any new specific form—would make its appearance during the period of embryonic life, and that if a new cat-species is to appear, it will appear as a kitten which differs more or less markedly from its parents. Such a birth is by no means against experience. It is not merely that minute changes occur—no two individual animals being absolutely alike—but every now and then a marked variation takes place, as in the case of the kitten seen by Mr. Birkett.* Such variations also are capable of being transmitted to the offspring of the animals in which they first arise.

But we may even gather some evidence in favour of the origin of species by considerable and not minute changes, from the special subject of this work—the group of Cats. Species of *Machærodus*, like *Smilodon*, were, as we have seen,† unable to kill by biting on account of the enormous length of their upper canines, which could only be used as daggers, the mouth being closed. All existing feline animals, including the long-tailed, clouded tiger (*F. macrocelis*), bite, and are unable to use their canines as daggers. Now, if the canines of *Machærodus Smilodon* had been formed by minute increase in successive generations, the creatures would at one time have been in a condition such that their teeth were too long to be conveniently used for biting, while they were not yet long enough to be efficiently used as daggers. It is true that there are different species of *Machærodus* with teeth of very different lengths, and it is also true that before the canines became so long as to be quite useless for biting, they would begin to be slightly useful as daggers. Still the fact remains that a highly inconvenient transitional stage of existence ‡ must have been passed through, if evolutionary changes were

* See *ante*, p. 7. Amongst new organic forms known to have been suddenly evolved are: The black-shouldered peacock, new forms of wild deer, a smooth capsuled kind of *Datura tatula*, a complex-capsuled form of poppy, &c., &c.

† See *ante*, p. 432.

‡ Professor Cope has said (see Proceedings of the Acad. of Nat. Sc. of Philadelphia for July 8, 1879):—"I think there can be no doubt that the huge canines in the Smilodons must have prevented the biting off of flesh from large pieces, so as to greatly interfere with feeding. . . . The size of the canines is such as to prevent their use as cutting instruments, excepting with the mouth closed, for the latter could not have been opened sufficiently to allow any object to enter it from the front. Even were it opened so far as to allow the mandible to pass behind the apices of the canines, there would appear to be some risk of the latter's becoming caught on the point of one or the other canine." As to the cause of the disappearance of this highly specialized form of life, Professor Flower has observed (in a lecture delivered at the Royal Institution on March 10, 1876):—"It may have been a case of over-specialization, in which the development of the carnivorous type of dentition, gradually accumulating in intensity . . . , became at last a successive inheritance so exaggerated that its growth outran its usefulness of purpose."

always *minute* changes. If, however, a sudden and considerable change took place, this difficulty, in the way of evolution, would be completely evaded. But what is here said of *Machærodus*, has a wide application. Were not forms of life evolved by a process which, compared with their duration, is "sudden," the world would be a zoological chaos. But such is not the case. A multitude of undoubtedly stable and plainly distinct kinds exist now, and thence we may conclude that stable and distinct kinds always existed, however difficult the definition of some forms may be in certain cases.

Returning from this digression to the question as to the mode of *individual* development and evolution, if we extend our view beyond the class of mammals, far more striking phenomena will present themselves to our notice than any with which we have become acquainted in studying the development of the cat. Thus in the development of such an animal as the frog, we find that two remarkable transformations take place. One of these is the transformation of the egg into a fish-like tadpole, the other is the transformation of the tadpole into the frog. In that singular species of Mexican eft, the axolotl, we find that a few individuals will every now and then (under the stimulus of certain conditions of their environment) quickly undergo a transformation, not merely of external appearance, but one which affects their very skeleton, and changes the distribution of the teeth in their jaws. In insects, as *e.g.*, in the butterfly, we have the well-known marvellous metamorphosis which is effected during the period of its existence as a quiescent chrysalis. Other lowly animals undergo still more surprising changes, which in many of them, as in the Tunicates, may result in the production of an adult form which is of a *lower* order of organization than that of the transient being which served to evolve it. Such facts as these show how probable it is, that at various different stages of individual evolution, sudden changes caused by an acceleration or by an arrest of the development process, or even by some retrogressive action, may have resulted not merely in the production in the concrete of new species, but even of a new genus, a new family, or a new order; for we see equivalent changes going on before our eyes now.*

. . Such appears to be constantly the fate of forms which have become over-specialized, or in which the development of one part has run on in one particular direction out of due proportion to the rest of the organization. We know that it is quite possible, by artificial selection, to produce animals with one particular part developed even detrimentally to the entire economy of the creature, and it really seems as if something of the same kind not unfrequently occurs in nature." It is *indeed* true that for the perfection of any living creature there is need of harmony between its various powers, and a moral may be drawn from the above instance as to the dangers likely to result to any race of mankind from a one-sided, ill-balanced development of those intellectual powers which give man supremacy over all lower forms of life.

* Some readers may feel a difficulty in accepting the view here put forward (as to the serial succession of different psychical principles of individuation in the development of each individual animal such as the cat, frog, or butterfly), on account of the gradual mode in which even rapid metamorphoses take place.

The tadpole only by *degrees* becomes a frog, and gradual processes of change take place within the seemingly quies-

§ 13. It may be said that we even see the fresh starting forth of life itself. In many plants, the ovule (after developing to that extent which is its condition in the fully formed seed) ceases to be active. The seed is shed and dies. But on the occurrence of the requisite conditions, it lives again and comes rapidly to manifest a new psychical principle of individuation altogether different from that which informed the same matter when it was a developing seed. It may, perhaps, be objected by some persons that: "if the seed is not actually living during its period of quiescence, the result shows that it has nevertheless been potentially alive." But it is impossible to understand how anything can be really "alive" when all vital activity is really absent, and no such activity can be affirmed to exist during the long periods * in which dry seeds may be preserved without decomposition. The "vital activity" of a seed is "germination."

As to "potential life," its existence may be freely conceded; but *potential* "life" is *actual* "death." The "potentiality" is not in the seed merely, but in the environing conditions and external stimuli also, yet "life" is not to be predicated of such "conditions" and "stimuli." The dead seed is but a piece of matter so appropriately formed that if it and other matters are brought together under certain conditions, a new living being results from the conjunction. This is but a case of that genetic activity which all persons who believe that life first arose spontaneously in the world, must admit to have once existed, and if "once," why not "always?"

§ 14. But how are all the changes of development in the cat and in all animals and plants, carried on? Is it by a number of fortuitous

cent chrysalis. It may be asked then: How can a new "form" *suddenly* arise, when the body it informs arises *gradually*? But are not a piece of oak, and woodashes, different substances? Yet does not fire *gradually* effect the transformation of the former into the latter?

Our organs of sense are indeed so constructed and so act that they are incapable of positively seeing any absolute commencement whatever. When we seem to perceive such a thing (as, *e.g.*, in the explosion of gunpowder), the apparent absolute suddenness is but due to the fact that the gradual changes which really take place are too minute and too rapid for our sense-organs to follow. There can be no doubt but that if our powers of sense were in these respects greatly augmented, an explosion of gunpowder would then be seen by us to be a gradual process.

But the emergence of a new psychical principle of individuation is a thing which is and must ever remain *essentially* imperceptible to our senses, however much their powers might be augmented. Each such psychical principle can—as we know by our own personal experience—

continue to inform a body while that body undergoes various changes and gradual modifications within certain limits; but will cease so to exist when once those limits are passed. The actual amount of change which the body of a developing animal can undergo while informed by any one principle, and the physical conditions which determine the lapse into potentiality of that principle and the advent of another, may remain a matter of speculation only. There appears, however, to be evidence that such changes actually take place, and the gradual preparation of the living matter for their occurrence is a phenomenon which harmonizes with our experience as to the only psychical principle of individuation of which we have thorough knowledge—our own.

* Mr. Carruthers, F.R.S., has kindly informed me that seeds of *Nelumbium* (a beautiful aquatic plant belonging to the Lotus group) have germinated after having been preserved in the British Museum for upwards of a hundred years. In this case it is manifest that all vital activity was for a very long time really absent.

changes, and by phenomena without order, and apparently subject to no law? Surely it is the very reverse! The transformations, the successive embodiments of new ideas of all ranks and degrees, which are daily taking place in countless myriads on all sides of us, take place harmoniously and in due order. However singular or surprising may be the process of evolution in certain cases, however round-about its course, or unexpected its intermediate stages and ultimate outcome, it is in each and every case a process carried on according to definite internal laws to fulfil a precise * and predetermined end.

What we find to be the case now, we ought, if we are to take experience as our guide, to regard as having been the case antecedently. Thus the process of specific evolution in the past will have been no process effected by a fortuitous concourse of influences, or by minute haphazard variations in all directions, but by a definite system of internal law, aided and influenced in the past as it is aided and influenced now, by the action of incident forces, also operating according to law, and resulting in due and orderly "*specific genesis.*"

§ **15** The idea of an INTERNAL FORCE is a conception which we cannot escape if we would adhere to the teaching of Nature. If, in order to escape it, we were to consent to regard the instincts of animals as exclusively due to the conjoint action of their environment and their physical needs, to what should we attribute the origin of their physical needs—their desire for food and safety, and their sexual instincts? If, for argument's sake, we were to grant that these needs were the mere result of the active powers of the cells which compose their tissues, the question but returns—whence had these cells their active powers, their aptitudes and needs? And if, by a still more absurd concession, we should grant that these needs and aptitudes are the mere outcome of the physical properties of their ultimate material constituents, the question still again returns, and with redoubled force. That the actual world we see about us should ever have been possible, its very first elements must have possessed those definite, essential natures, and have had implanted in them those internal laws and innate powers which reason declares to be necessary to account for the subsequent outcome. We must then, after all, concede at the end as much as we need have conceded at the outset of the inquiry.

Potent amongst the agents operating in the process of specific evolution must be that internal, individual, psychical force—that soul or psyche—which we have seen reason postulates as the most important, though invisible, constituent of every concrete living whole. It must play this predominant part, because it is by its action that the whole multitudinous and diverse processes of life are co-ordinated

* Some persons may think that the occurrence of monstrous births, &c., constitutes an objection to the above statement. No one however imagines that the fact of a man becoming lame through some accident is in contradiction with the harmony of Nature's laws. But an accident occurring before birth is no more in contradiction with such harmony than is an accident to an adult.

and controlled into that unity which we perceive in each separate living organism.

All nutrition, growth, and reproduction are normally controlled and ultimately effected by it, no less than all motion, feeling, and cognition. Therefore it is by it that those physical changes are effected which, during the process of individual development, so change the conditions of the matter of the body, as, by degrees, to render it unsuitable for the form actually embodied in it, and to prepare it to receive that form which comes next in the order of evolution.

§ **16.** This is what is really meant by the assertion that the genesis of species takes place mainly through the agency of an internal force,* and this mode of origin may—as opposed to the hypothesis of natural selection—be fitly termed PSYCHOGENESIS.

§ **17.** But the further question may yet be asked, what determines the origin of species by psychogenesis? What controls and directs the successive evolutions and disappearances of these various "forms" or psychical principles of individuation—"forms" which ever arise in due order and succession now, and which we may therefore infer to have arisen in due order and succession through the countless ages of past organic activity?

To this question no reply is possible without passing from questions of physical science to the highest problems of philosophy. But no natural object can be fully understood without reference to such problems, and to shrink from explicitly referring to them here, would be a dereliction of scientific duty. The consideration of the action and nature of no cause which there is reason to suppose influences the formation of living creatures, can fitly be omitted from the study of the evolution of any form of life.

The observer of nature who contents himself with considering external phenomena and does not reflect on his own intellectual powers and the similar powers of his fellow-men—such a partial observer of nature may perhaps conceive of the cause thus operating in evolution as unintelligent. He may deem it to be some principle utterly inconceivable by us, pervading all space and enduring through all time, yet devoid of consciousness and will. He may deem it to be a force incapable of apprehending what it produces, but which is at the same time the origin of all law, all beauty, and all intelligence.

But let us see what such a conception really means. It is admitted that we cannot transcend experience. We cannot then imagine a first cause save in terms the elements of which are within

* This conception, put forward in "The Genesis of Species," seems to be now practically admitted, even by the author of "The Origin of Species," for the latter has come to admit that "abrupt, strongly marked changes," may occur "neither beneficial nor injurious" to the creature which exhibits them, produced by "unknown agencies" lying deep in "*the nature of the organism!*" It is hardly necessary to point out that with respect to such developments, "Natural Selection" must be absolutely impotent. Upon such changes it cannot possibly exert any influence whatever.

at experience. Now the highest entities thus known to us are uman intellect and human will. Besides these, we know only the erely animal, the vegetal, and the inorganic worlds. Should e then imagine the Universal First Cause in terms of some gas or me merely physical force? Such a conception has but to be ated to show its absurdity. But if we attribute to the Great Cause, tive in organic nature, an activity which is intelligent in its sults, but not in itself—not in the agency which produces those sults—we thereby attribute to it a sort of *instinct*, and, in order to oid the error of *anthropomorphism*, we fall into the vastly greater, d more absurd, error of *zoomorphism*!

We have no choice, then, but to imagine this Great Cause in rms derived from human nature while confessing their inadequacy d being careful to render them as little inadequate as is possible, considering all that is positive in them as raised to infinity, and the same time eliminating from the conception all that is negative d imperfect.

When, however, extending our view over the whole of Nature, e include in our study man's faculty of apprehending truth, good- ss, and beauty, together with his wonderful power of occasionally ntrolling by his free will his own thoughts, desires, and actions, and actively intervening in the chain of physical causation, the idea of e first cause as God becomes evident to the mind; nor can it be jected without self-stultification. The denial of the validity of is inference involves a negation of facts and of intellectual prin- ples, which negation carried out to its logical consequences destroys self by the sceptical destruction of those very premises on which at denial must itself repose.

The philosopher then has the strongest possible ground for affirm- g (in reply to the question as to the cause of Psychogenesis) that the process of evolution we have evidence of the activity of a reat First Cause, ever and always operating throughout nature in manner hidden indeed from the eye of sense, but clearly mani- sted to the intellectual vision of every unprejudiced mind. This ction is that secondary or derivative creation,* "*per temporum oras*," distinguished by St. Augustine, from that instantaneous rimary creation which took place, "*potentialiter atque causaliter*," the beginning. Thus a belief in "evolution" far from leading to denial of "creation," distinctly affirms it.

Indeed the candid study even of merely organic life makes vident the logical need which exists for the Theistic conception. he course of individual development as it goes on in every kitten, hows the existence of a *final*, no less than of an efficient cause of he developmental process. Anyone who would pretend that the ere conflict of independent efficient causes can produce a co-ordi- ated series of effects, resulting in the attainment of a definite end, hich they have all concurred to produce, would certainly go against

* See "Lessons from Nature," p. 429.

all our experience. Anyone, also, who should pretend that we cannot affirm a "purpose" to exist in different natural processes (*i.e.*, who denies that we can assert a "final cause" for any phenomenon) because we are unable to state the final cause of the whole series of physical phenomena, would be like a soldier who, because he was ignorant of the plan of campaign of his commander-in-chief, should pretend that therefore he could not infer that commander's purpose in sending medical stores to the military hospital.

The co-operation of a variety of actions under complex conditions in the production of something which works well and which is the admirable practical result of their harmonious co-operation, supposes, as our experience shows, a cause in which that future phenomenon is ideally represented; and the more complex the conditions, and the more numerous the actions may be, the more certainly may the conclusion be drawn that such prevision existed.

The Theistic idea once accepted, how does the action imminent in nature accord with our idea of God, thus conceived?

Surely it is just that sort of action which was to be expected. It is an action which harmonises with man's reason, which is orderly, constant, and universal, yet which ever eludes our grasp, and is effected by ways and in modes very different from those by which we should have attempted to accomplish such ends.

As to "creative action," reason tells us nothing more than that its existence must be logically inferred. It *could* tell us nothing more, since of it we cannot possibly have had any experience whatever. Those men are strangely inconsistent who would deny it because they cannot imagine it, since they must confess that it may be unimaginable by them (even if they were in some way made certain of its existence) on account of their never having had any experience of it.

§ **18.** But to revert to the question of the Origin of Species. Let it be granted that Divine activity evolves new concrete forms by final and efficient causes (making use of living organisms as means), are these all the causes which operate, or is there yet another cause?

Species, genera, families, orders, and classes, as such are ideas; they have an ideal existence in the human mind—have they no other ideal existence? Every Theist must admit that the mind of God contains all that exists in the human mind, and infinitely more. It is therefore a simple truism to say that human general conceptions, gathered from nature, must be ideas in the Divine mind also—such human conceptions being but faint and obscure adumbrations of corresponding ideas which must exist in their perfection and fulness in the mind of God. But there is yet a further consideration. Our ideas are ideas derived from material things, while the Divine ideas are ideas whence material things have been themselves derived. This must be so, since God is eternal, and these ideas, as His, must be eternal also; whereas all the most ancient concrete existences in which such ideas are embodied, are relatively but creatures of yesterday.

Human ideas are "true," in so far as they correspond with really existing things external to the human mind. But really existing, external things are themselves "true," in so far as they correspond with the eternal, archetypal or prototypal ideas of God which are their *exemplar cause*.

The wondrously varied world of phenomena which presents itself on every side to the human senses, is to those senses but a confused mixture of sounds and colours, odours, tastes, and touches. It is *the intellect* which puts ideal order into the sensuous chaos, recognising subjectively that external order which in fact exists objectively. Amongst the orderly phenomena which cultivation enables the intellect to apprehend, are the variously related ideal conceptions—species, genera, families, orders, and classes—which have their objective reality and foundation in the actually existing characters of concrete material objects. We are able, moreover, not only to recognize that these ideas exist, but also to recognize that they form a hierarchy of conceptions. We thus come to apprehend that an idea embodied in some large group of creatures—some order—is carried to a more thorough and definite expression in some one family of that order, and to a still more intense degree in some genus of that family. It is thus that we recognize in all beasts the concrete embodiment of the mammalian idea, and in the carnivorous type, a special, perhaps the highest, expression of that idea, which is carried out to its fullest manifestation in the typical Felidæ.

We see then that the feline form is the most complete expression yet realized of that exemplar ideal which is less fully expressed by the carnivorous order considered as a whole. Thus viewed, the creatures to the special consideration of which this work is devoted, are seen to exhibit multiform relations of a very elevated character. Evolved through the action of antecedent organisms (of increasing specialization of structure) as their *efficient cause*, they have for their *final cause*, the external realization in the material creation of one of those prototypal ideas which are the several *exemplar causes* of the world of organic life, and which have eternally preceded every creative act. Interesting then as the animals which have here occupied us are to the zoologist, the physiologist, the geographer, the geologist, and the psychologist, they are most of all interesting to the philosopher. The true philosopher will never rest satisfied with a knowledge of material and efficient causes alone, but will ever seek to obtain what glimpses he may of those other causes which his reason tells him can never be absent from a world which is the outcome of a Divine Intelligence. Only at last will he rest satisfied, when, having traced as far as he may, the series of secondary causes, he is able confidently to refer to the evident though hidden action of the Great Author of Nature. Reason exhibits to us the whole Cosmos as proceeding from Him, and only when the study of his creatures ends by leading the student back to Him from whom they proceeded, can that study be said to be "rational" in the highest sense of that word. Then only is it truly worthy of that admirable

human intellect which sees in the concordance between subjective reason and the rational laws of the objective universe, evidence that the human intellect itself has been created in the image and likeness of that intellect which is Divine.

§ **19**. Our endeavour in the pursuit of knowledge should be humbly but zealously to follow that natural impulse implanted in us, to synthesize as well as to analyse, and above all to be untiring in the pursuit of causes. Of the scientific man it may indeed be said:

Felix qui potuit rerum cognoscere causas.

No knowledge of mere facts and phenomena, however multitudinous and varied, will suffice to constitute "SCIENCE." The essence of all science is a knowledge of CAUSES, and only when all the phenomena embraced by any given study have been referred to their immediate causes, and when all their more remote causes have been duly investigated, and their several inter-relations clearly understood, will that study be able to take its place as a perfected "science." Great has been the progress of this kind which Biology has made during the last half century. Full of hope and promise is the prospect before it, long as must be its course before its perfected condition can be attained.

§ **20**. To help on its progress, no course is perhaps more useful than that of the careful study of a succession of TYPES belonging to different families of living beings. Amongst the multitude of such groups, that one has been here selected for examination which has been deemed most likely to be useful to the earnest enquirer in biological science who is beginning such a course of study. No more complete example of a perfectly organized living being can well be found, than that supplied by a member of what has no in considerable claims to be regarded as the highest mammalian family —the family *Felidæ*.

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